SPACEWOUND COMPOSITE STRUCTURES

CONTRACT DAAJ02-77-C-0016

FINAL REPORT

JANUARY 1978

BY

DALE ABILDSKOV
SAM YAO

SUBMITTED BY:

FIBER SCIENCE, INC.
GARDENA, CALIFORNIA

FOR

U.S. ARMY RESEARCH AND TECHNOLOGY LABORATORIES
FORT EUSTIS, VIRGINIA

FIBER SCIENCE, Inc.

Approved for public release
Distribution unlimited

Best
Available
Copy

DDC AVAILABILITY NOTICES

1. Approved for public release; distribution unlimited.

2. Distribution limited to U. S. Gov't. agencies only; (state reason indicted in a, b, c, d or e); __________(date statement applied). Other requests for this document must be referred to the Eustis Directorate, US Army Air Mobility Research and Development Laboratory, Fort Eustis, VA 23604.

   a. __ Classified

   b. __ Contractor Performance Evaluation

   c. __ Foreign Information

   d. __ Proprietary Information

   e. __ Test and Evaluation

DISCLAIMER

3. The findings in this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

4. When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the US Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission, to manufacture, use, or sell any patented invention that may in any way be related thereto.

5. Trade names cited in this report do not constitute an official endorsement or approval of the use of such commercial hardware or software.

DISPOSITION INSTRUCTIONS

6. Destroy this report when no longer needed. Do not return it to the originator.

7. When this report is no longer needed, Department of the Army organizations will destroy it in accordance with the procedures given in AR 380-5.

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER (6)	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle) Spacewound Composite Structures,	5. TYPE OF REPORT & PERIOD COVERED (9) Final Report. Jan-Nov 77 (Contractor Format)
(10)	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Dale/Abildskov, Sam/Yao	8. CONTRACT OR GRANT NUMBER(s) (15) DAAJØ2-77-C-ØØ16 NEW
9. PERFORMING ORGANIZATION NAME AND ADDRESS Fiber Science, Inc. 245 East 157th Street Gardena, CA 90248	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 63211A, 1L263211DB41 ØØ EK (16) (17)
11. CONTROLLING OFFICE NAME AND ADDRESS Applied Technology Laboratory, USARTL (AVRADCOM) Ft Eustis, VA 23604	12. REPORT DATE (11) January 1978
	13. NUMBER OF PAGES 71
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) (12) 116p.	15. SECURITY CLASS. (of this report) Unclassified
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for Public Release, distribution Unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Composites	Spacewound
Fiberglass	Fuselage Structures
Kevlar	Ballistic Tolerance
Graphite	Survivability
Tailbooms	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The objective of this program was to investigate the potential of the spacewound structural concept to provide a ballistic tolerant structure to the high explosive projectile. The spacewound structural concept, developed by Fiber Science, Inc., is an open weave wet filament wound composite structural concept which has the potential for venting the blast pressure from the high explosive projectile while at the same time providing a multiplicity of redundant load paths.

(Continued)

DD FORM 1473 1 JAN 73 EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified LB

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

388 573

Block 20. Continued

Twelve 24-inch diameter cylindrical specimens were designed and fabricated by Fiber Science, Inc., and were subsequently ballistically tested at the Applied Technology Laboratory, Fort Eustis, Virginia. Three materials (Kevlar, Fiberglass, and Graphite), two fiber coverage ratios, and the use of an external fiberglass aerodynamic skin surface were assessed. Based on the results of these tests, four kevlar specimens with a fiberglass cloth skin, two with 25% and two with 50% fiber coverage ratio, were selected for final design evaluation. The final specimens were 16-inch diameter cylinders with a four-bolt ring/frame attachment fitting at each end to facilitate structural testing.

The final design specimens were subsequently structurally tested both before and after high explosive projectile ballistic tests at the Applied Technology Laboratory. A final report describing the test program and results is currently in preparation.

SPACEWOUND COMPOSITE STRUCTURES

CONTRACT DAAJ02-77-C-0016

FINAL REPORT

JANUARY 1978

BY

DALE ABILDSKOV
SAM YAO

SUBMITTED BY:

FIBER SCIENCE, INC.
GARDENA, CALIFORNIA

FOR

U.S. ARMY RESEARCH AND TECHNOLOGY LABORATORIES
FORT EUSTIS, VIRGINIA

Approved for public release
Distribution unlimited

FOREWORD

This report was prepared by Fiber Science, Inc. in accordance with Contract DAAJ02-77-C-0016, issued by the Eustis Directorate, U.S. Army Air Mobility Research and Development Laboratory, Fort Eustis, Virginia*. Mr. DAN GOOD ~~Eddie Dean~~ was the U.S. Army program technical monitor.

The activities reported herein cover the period from January 1977 to November 1977. The Fiber Science project engineer was Mr. Sam Yao.

*Redesignated Applied Technology Laboratory, Research and Development Laboratories (AVRADCOM), 1 September 1977.

SUMMARY

Six configurations of Spacewind cylinders were designed to a prescribed set of strength and stiffness criteria. The variables were two levels of fiber coverage and three reinforcements; glass, Kevlar and graphite. One cylinder of each design was fabricated at Fiber Science and tested for ballistic tolerance at Fort Eustis.

Four more cylinders were fabricated for final testing. The variable was two levels of fiber coverage. Kevlar 49 was the reinforcement for all four.

TABLE OF CONTENTS

LIST OF TABLES & FIGURES

INTRODUCTION

"Spacewind" is a descriptive term applied to the filament winding process used in this contract. Normal filament winding procedures are very specific in requiring bands to be exactly adjacent to each other. Spacewind nomenclature for a structure with adjacent bands would be "1.00 fiber coverage ratio." That is, the ratio of surface area covered by strands to the total surface area is 1.00.

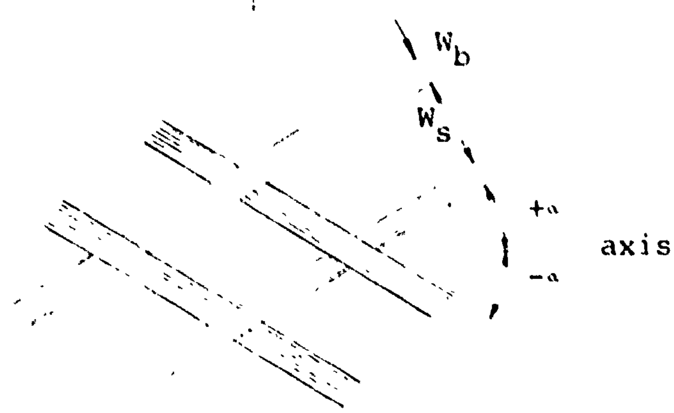
Spacewind deliberately requires spaces between roving bands. The final structure, regardless of wall thickness, looks like it is made of old fashioned cane or wicker because there are holes geometrically arranged over the entire surface.

A non-standard language has developed to explain the non-standard filament winding process called Spacewind. The following definitions will help in reading this report.

Strand	A general term indicating an essentially continuous length of filamentary material, whether large or small, twisted or untwisted.
Band Width	A single strand might be wound or several strands might be gathered and wound at one time. Band width is the width of the total number of strands wound at one time.
Winding Angle	Strands are wound onto a rotating mandrel by traversing from end to end of the mandrel. The angle between a strand and the

mandrel axis is the winding angle. It is both + and - with reference to cartesian coordinates since the band direction changes.

F.C.R. Fiber Coverage Ratio is the ratio of mandrel surface area covered with strands going in one direction to the amount not covered, as sketched below. F.C.R. is used as an easily calculated expression for Spacewind.



$$F.C.R. = \frac{W_b}{W_b + W_s}$$

F.A.C.R Fiber Area Coverage Ratio is the area covered by fibers divided by total surface

area, realizing that bands run both left and right.

Fiber Volume — A second ratio, unrelated to F.C.R., is the ratio of fiber volume to the total volume of fiber and resin.

A prior contract, DAAJ02-76-C-0040, administered by the Applied Technology Laboratory, Research & Technology Laboratories, Fort Eustis, Virginia, had demonstrated it is possible to use analytical models in designing Spacewind composites. This contract was intended to evaluate the potential of Spacewind as a structure with built-in pressure relief valves.

Explosive projectile fire directed at modern Army aircraft is often fatal because the overpressure from the blast requires the fuselage to become a pressure vessel. Fuselages are not designed as pressure vessels because of a very large associated weight penalty. The result is structural failure from a blast which might be insignificant in terms of damage from shrapnel. Spacewind was considered a possible solution to overpressure from explosive projectiles because it has multitudes of built-in pressure relief vents.

Six cylinders 24 inches in diameter and 72 inches long were specified as a vehicle for evaluating the ballistic tolerance of Spacewind. Three reinforcements, S-2 glass, Kevlar 49 and graphite were specified for evaluation. All six cylinders were to be designed to the following stiffness and strength requirements.

Stiffness: $EI_y = 2.6 \times 10^9$ lb-in^2 (flexural stiffness about 'y' axis)

$EI_z = 2.6 \times 10^9$ lb-in^2 (flexural stiffness about 'z' axis)

$GK = 1.2 \times 10^9$ lb-in^2 (shear stiffness)

Limit Load: $M_x = 1.37 \times 10^5$ in-lbs (bending moment about 'x' axis)

$M_z = 3.87 \times 10^5$ in-lbs (bending moment about 'z' axis)

$S_z = 1.14 \times 10^3$ lbs (shear in the 'z' direction)

NOTE: The 'x' axis is the longitudinal axis of the cylinder.

Following testing of these sections by the Army four more cylinders 16 inches in diameter by 72 inches long were designed using Kevlar 49 as the reinforcing fiber. These specimens included four attachment fittings at each end to facilitate structural testing. The design criteria used for these four cylinders were:

Stiffness: $EI_y = 1.1 \times 10^9$ lb-in^2

$EI_z = 1.1 \times 10^9$ lb-in^2

$GK = 0.5 \times 10^9$ lb-in^2

Limit Loads: $M_x = 1.2 \times 10^5$ in-lb

$M_z = 1.53 \times 10^5$ in-lb

$S_z = 2.84 \times 10^2$ lb

$S_y = 2.922 \times 10^3$ lb

Following sections give design data and fabrication techniques for these cylinders. All testing was performed by the Army Air Mobility Research and Development

Laboratory, Fort Eustis, Virginia.

DESIGN

Design equations are given in Appendix A and design calculations based on these equations are given in Appendix B.

One primary design consideration was whether to design single wall or sandwich wall structures to meet the stability requirements. A foam core in a sandwich wall would not be acceptable because it would block off all the Spacewind holes which were being considered pressure relief valves. Honeycomb could be used, though, because of its construction. Stability calculations showed that only the fift -percent F.C.R. graphite specimen required sandwich wall construction.

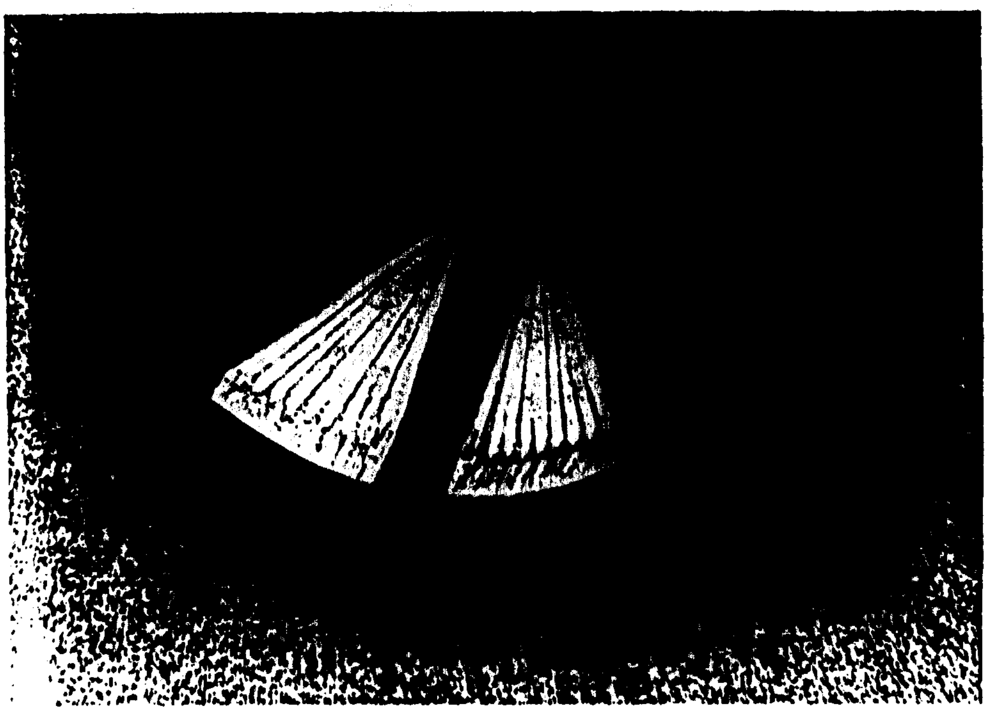
The structural requirements given earlier apply to cylinders supported at its ends with bending forces applied. These requirements are best met by strands wound at a very small angle to the cylinder axis. A hoop load was also known to be a requirement to resist overpressure loads. Its magnitude was unknown, so hoop strength could not be designated.

Past design experience led to an empirical feeling that twenty-percent of all strands should be hoop, or circumferential, strands. These strands do not contribute significantly to the strength and stiffness requirements, but do contribute to ballistic tolerance. The balance of strands were calculated to be ± 24 degrees to the cylinder axis.

The six cylinders were fabricated at Fiber Science and tested at Fort Eustis. Kevlar 49 was selected as the reinforcement for the final demonstration cylinders.

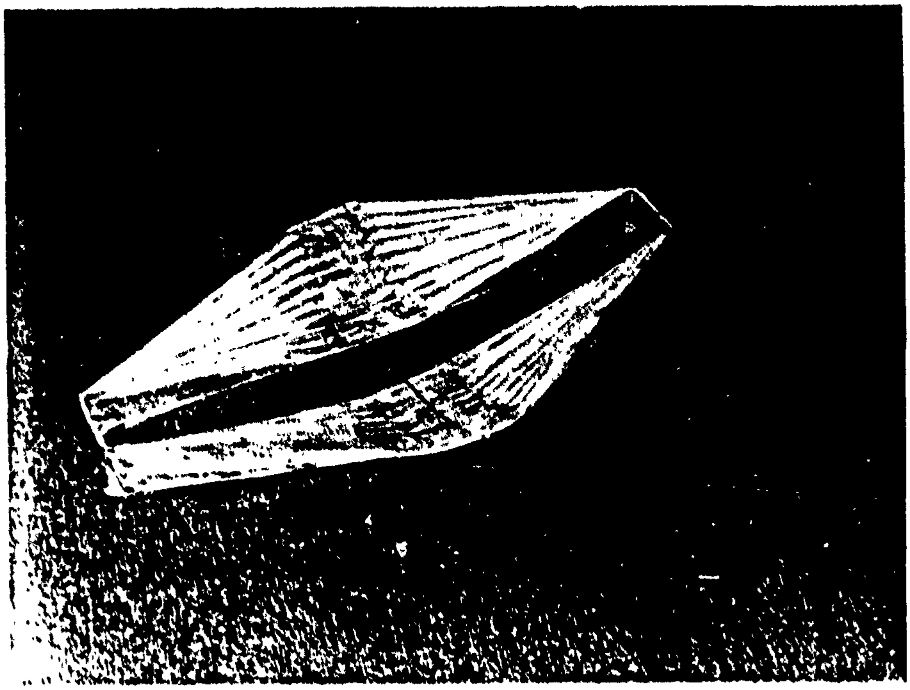
The final demonstration units were made smaller in diameter in an effort to increase the overpressure loads and to have a more severe test. They also had to have end fittings so they could be loaded in bending at the time of projectile testing.

Design calculations for the fittings are in Appendix C. The concept employed is one used previously at Fiber Science and referred to as a broom. A broom fitting is shown below.

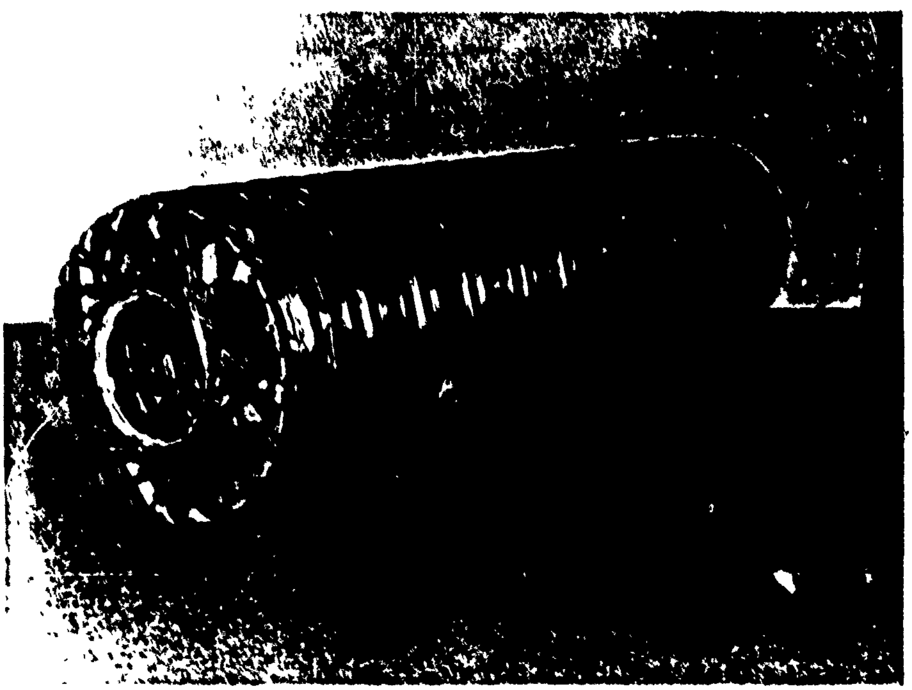


Glass rovings were wound into a circular, unidirectional package and then transferred to a mold. The circular rovings were deformed in the mold to make two fittings,

end to end, as shown below.



A closure flange for the cylinder was designed to back up the fittings and rovings were wound over it as shown below.



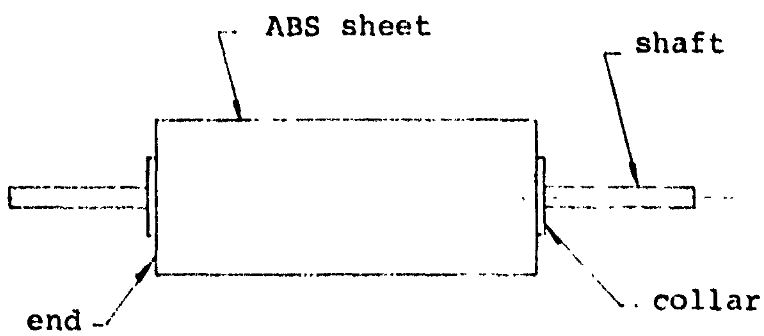
The attach fittings were then bonded inside the cylinder at four places on each end. A force applied to one or more fittings is transferred to the mounting ring and thereby to the rovings as well as to the rovings by adhesive bond shear.

These four cylinders were fabricated and delivered to Fort Eustis for testing.

FABRICATION

Cylinders were wound on standard helical filament winding machines. The machines were programmed to give the pattern desired and that program was used for all three reinforcements.

Tooling was composed of a steel shaft, steel collars, glass composite ends and an ABS sheet cylinder as sketched below.



Ends were bolted to the collars, which in turn were bolted to the shaft. The ABS sheet was bonded to the ends and then was pressurized at 1 PSI with air to stabilize it. The outer surface was coated with mold release so it could be removed after winding and curing the cylinders.

The last four demonstration cylinders had flanged end plates built in. These plates were made from ten plies of Style 1581 glass fabric impregnated with epoxy resin. They fit over the fiberglass tooling ends and were wound

over with rovings, which prevented the tooling from being removed in one piece.

Glass composite tool ends for these cylinders were cut in half and sealed together again before the ABS sheet was bonded on. After the cylinder was cured, ends were unbolted from collars and pushed into the cylinder. They then were removed in half pieces, ready to be used again.

Fittings were made from glass fibers and epoxy resin by filament winding around two spools. The windings, before being cured, were moved to a fiberglass mold and deformed to the correct shape and then cured. The resulting structure was two fittings, formed end-to-end. It was cut in the middle to yield two fittings.

Properly located holes were drilled in the wound and cured cylinders. Fittings were mated to the holes on the inside of the tank and adhesive bonded into place.

There were no fabrication problems in winding or assembly.

TESTING

The first cylinders made were 24 inches in diameter and 92 inches long. These were cut in half (46 inches long) at Fort Eustis and one-half had a single ply of 181 glass fabric laminated on to simulate the skin on an aircraft. Twelve variations were tested as shown below.

Reinforcement	FCR	Skin
Glass	.25 & .50	with and without
Kevlar	.25 & .50	with and without
Graphite	.25 & .50	with and without

Table 1. Ballistic Samples Tested

Samples were held in a fixture and fired upon. Results were evaluated by Fort Eustis personnel as follows.

Damage Assessment

1. To assess the relative damage to the specimens as a result of the 23mm HEI-T ballistic impact tests, an inspection of the specimens was conducted in which the number of partially or fully severed fiber bands was tabulated.

   a. The number of severed fiber bands was counted on the top, bottom, and exit side of the specimens as shown in Figure 1. The damage on the entrance side was not considered for the following reasons.

      (1) The damage is relatively small compared to the top, bottom, and exit side damage.

(2) The damage on the entrance side is a function of whether the projectile passed through one or more bands or through the function plate.

b. The number of hoop bands and ± 24° bands was counted separately.

c. The degree of damage (i.e., percent of band severance) was estimated as being 25, 50, 75 or 100 percent.

d. The band damage data are shown in Figure 1. The damage levels were then weighted to arrive at a "Damage Coefficient". The weights are as follows:

Percent of Band Severed	Weighting Factor
25	1
50	2
75	3
100	4

The weighted points were then summed for each damage location and band direction. Then the points were summed over all damage locations to arrive at a damage coefficient for both the 24° and hoop bands.

2. It should be noted, however, that the loss of a given band in the 25% FCR specimens is more damaging than the loss of a band in the 50% FCR specimens in that the band thickness in the 25% FCR specimens is twice that of the 50% FCR specimens.

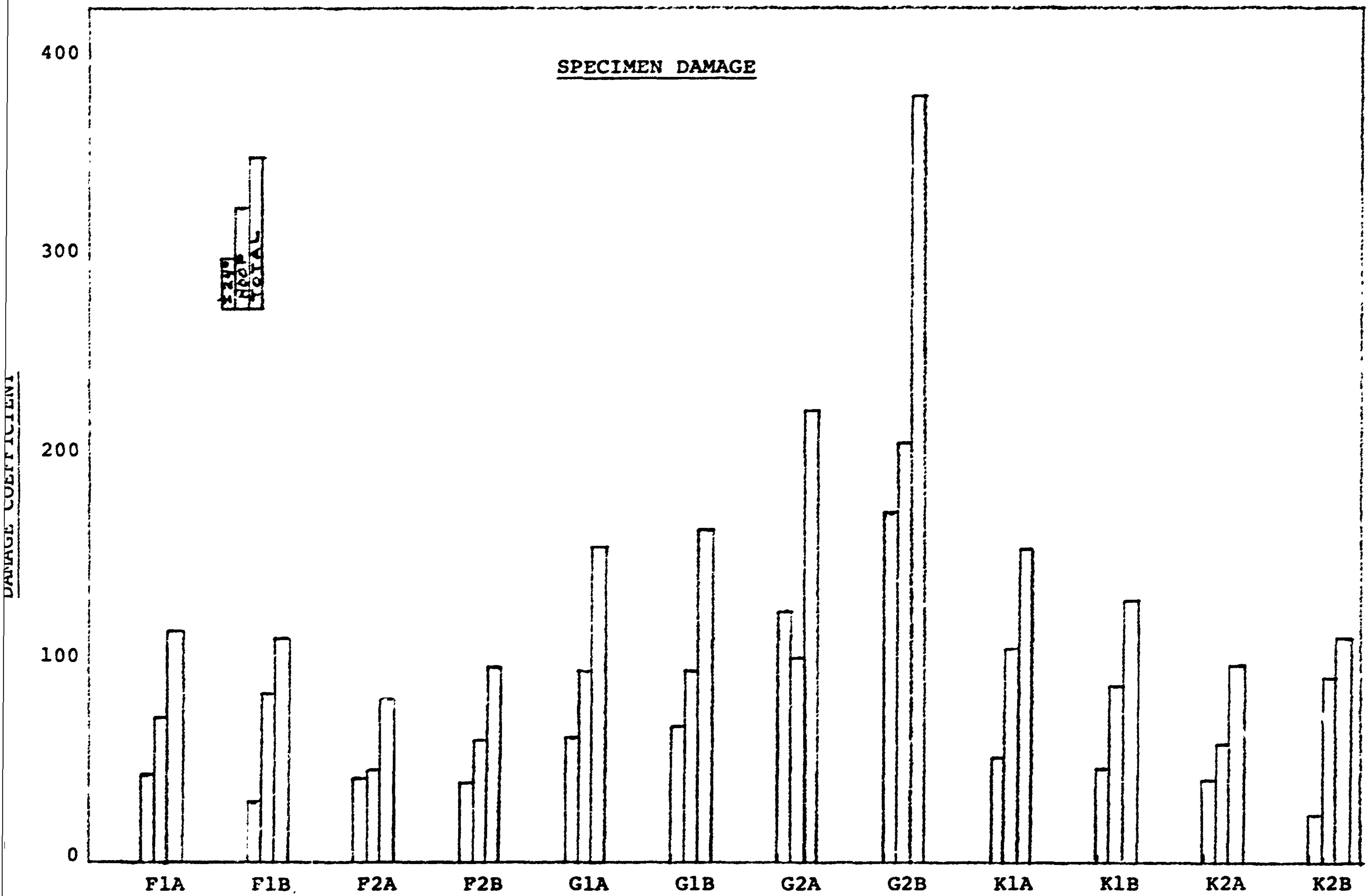


Figure 1. Band Damage Data

Samples were given the following code.

First Character

F = Fiberglass

K = Kevlar

G = Graphite

Second Character

1 = 25% FCR

2 = 50% FCR

Third Character

A = with #181 glass clothskin

B = no skin

Test results are graphed in Figure 1.

The effect of a skin is very small and perhaps none at all. Glass and Kevlar reinforced specimens tested quite similarly, while graphite was a clear third choice.

Weights of the various samples are given in Table 2.

Spacewind Composite Structures
Weight Analysis

Material	FCR	Weight		
		Calculated	Actual	
		No Skin	No Skin	With Skin
S-Glass	25%	29.58	33	35.75
S-Glass	50%	29.04	32	35.5
Kevlar	25%	14.66	17.63	20.27
Kevlar	50%	14.63	15.38	18.25
Graphite	25%	9.4	11.75	15.5
Graphite	50%	10.93	12.63	15.25

Table 2. Weight Analysis

Kevlar 49 samples are 40-50% lighter in weight than glass. The final demonstration samples were made from Kevlar reinforcement because of weight.

CONCLUSIONS

Test results indicate a single ply 181 glass covering over Spacewind cylinders has little, if any, effect on their ballistic resistance to 23mm HEI-T projectiles. Graphite reinforced cylinders suffer more damage, and perhaps less predictable damage, than glass or Kevlar reinforced cylinders. Spacewind appears to offer a solution to ballistic projectile over-pressure damage to aircraft fuselage structures.

APPENDIX A

SPACEWIND ANALYSIS EQUATIONS

SPACEWIND ANALYSIS EQUATIONS

The equations used in the design of the specimens follows:

Relation Between Modulus & Shear Modulus

$$I = \pi \bar{R}^3 t$$

$$K = 2\pi \bar{R}^3 t$$

$$\frac{E}{G} = \frac{(EI)K}{(KG)I} = \frac{2(EI)}{KG}$$

The above equations were used to establish the helical winding angle. This was accomplished by first assuming 20% of the winds would be in the hoop direction and 80% would be in the helical direction. The properties of spacewind composites were calculated using the computer with various helical winding angles and the helical angle which satisfied the above equation ($\frac{E}{G}$) selected.

Calculation of Outside Shell Radius

$$EI = \frac{\pi E}{4} (R_o^4 - R_i^4)$$

$$R_o = \left(\frac{4}{\pi} \frac{EI}{E} + R_i^4 \right)^{1/4}$$

Calculation of Maximum Bending & Shear Stresses

$$\sigma_{max} = \frac{M_z}{\pi \bar{R}^2 t}$$

$$\tau_{max} = \frac{M_x}{2\pi \bar{R}^2 t} + \frac{S_y}{\pi \bar{R} t}$$

Calculation of Critical Axial (Bending) Buckling Stress

Solid Wall Construction

$$\sigma_{cr} = C_c \left(\frac{E_e\ t}{\bar{R}} \right)$$

$$\bar{R} = \frac{R_o + R_i}{2}$$

$$C_c = 0.606 - .546\ (1 - e^n)$$

$$n = -\frac{1}{16} \sqrt{\frac{\bar{R}}{t}}$$

$$E_e = \frac{2\ E_x\ E_y}{E_x + E_y}$$

Sandwich Wall Construction

$$\sigma_{cr} = \frac{G_e\ (t_c + t_f)}{2\ t_c\ t_f}$$

$$G_e = G_c\ (FACR)$$

Note: FACR - Fiber Area Coverage Ratio

Calculation of Critical Distance Between Cross-over Points

The critical length between cross-over points of the helical windings is calculated by equating the buckling stress to the compressive strength of the helical windings.

Solid Wall Construction

$$P_{cr} = \frac{\pi^2 E_e I}{L_{cr}^2} \qquad \text{(pin ended column)}$$

$$\sigma_{cr} = \frac{P_{cr}}{t} = \frac{\pi^2 E_e t^2}{12 L_{cr}^2}$$

$$L_{cr} = \sqrt{\frac{\pi^2 E_e t^2}{12 F_{cu}}}$$

$$E_e = \frac{E_{11}}{2}$$

$$F_{cu} = \frac{F_{cu\,11}}{2}$$

Sandwich Wall Construction

$$P_{cr} = \frac{\pi^2 E_e I}{L_{cr}^2} \qquad \text{(pin ended column)}$$

$$I = \frac{(t_c + 2 t_f)^3}{12}$$

$$t_f = \frac{t}{2}$$

$$E_e = \frac{E_{11}}{2}$$

$$F_{cu} = \frac{F_{cu\,11}}{2}$$

$$\sigma_{cr} = \frac{P_{cr}}{t} = \frac{\pi^2 E_e (t_c + t)^3}{12 L_{cr}^2 t}$$

$$L_{cr} = \sqrt{\frac{\pi^2 E_e (t_c + t)^3}{12 F_{cu} t}}$$

When the core is weak in shear

$$\sigma_{cr} = \frac{G_e (t_c + t_f)}{2 t_c t_f}$$

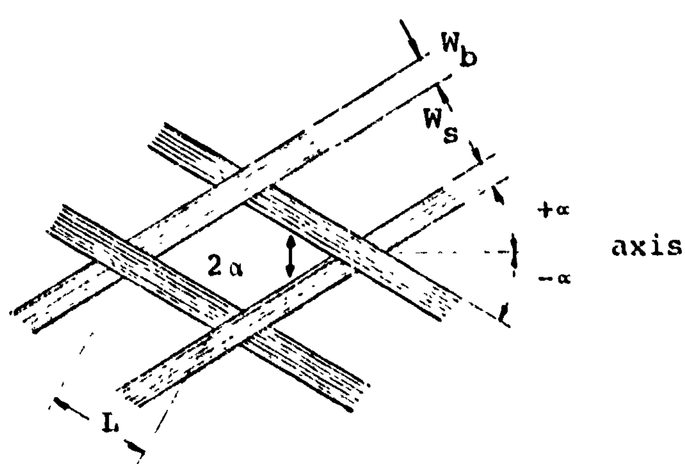
$$G_e = G_c \text{ (FACR)}$$

Note: FACR = Fiber Area Coverage Ratio

Fiber Coverage Analysis

Fiber Coverage Ratio "FCR"

$$\text{FCR} = \frac{W_b}{W_b + W_s} \qquad \text{(by definition)}$$



$$W_b = \frac{W_s\ (FCR)}{1 - FCR}$$

$$\sin 2\alpha = \frac{W_s}{L}$$

$$W_s = L\ 2 \sin\alpha \cos\alpha$$

The open area between helical bands is

$$\text{Open area} = W_s L = \frac{(W_s)^2}{2 \sin\alpha \cos\alpha}$$

The total area including fiber coverage to mid point of helical bands is

$$\text{Total area} = \frac{(W_s + W_b)^2}{2 \sin\alpha \cos\alpha}$$

The fiber area coverage ratio (FACR) is

$$FACR = 1 - \frac{\text{Open Area}}{\text{Total Area}} \quad \text{(by definition)}$$

$$FACR = 1 - \frac{(W_s)^2}{(W_s + W_b)^2}$$

Note: $W_b = \frac{W_s\ (FCR)}{1 - FCR}$

$$FACR = 2\ FCR - (FCR)^2$$

FCR	FACR
.250	.4375
.375	.6094
.500	.7500
.625	.8594
.875	.9844

The fiber area coverage ratio for both circimferential and helical windings is

$$\text{FACR} = (\text{FACR})_h + \left[1 - (\text{FACR})_h\right] (\text{FACR})_c$$

Note:

$$(\text{FACR})_h = 2(\text{FCR})_h - (\text{FCR})_h^2$$

$$(\text{FACR})_c = (\text{FCR})_c$$

$(\text{FCR})_h$	$(\text{FACR})_h$	$(\text{FCR})_c$	$(\text{FACR})_c$	(FACR)
.250	.4375	.250	.250	.5781
.375	.6094	.375	.375	.7559
.500	.7500	.500	.500	.8750
.625	.8594	.625	.625	.9173
.875	.9844	.875	.875	.9981

The fiber cross-over area (FCOA) for helical windings is

$$\text{FCOA} = \frac{W_b^2}{2 \sin\alpha \cos\alpha}$$

The fiber area (FA) is

$$FA = \text{Total area} - \text{open area}$$

$$FA = \frac{(W_s + W_b)^2 - (W_s)^2}{2 \sin\alpha \cos\alpha}$$

The fiber cross-over coverage ratio is

$$\frac{FCOA}{FA} = \frac{(W_b)^2}{(W_s + W_b)^2 - (W_s)^2} = \frac{W_b}{W_b + 2W_s}$$

$$\text{Noting } FCR = \frac{W_b}{W_b + W_s}$$

$$W_s = \frac{W_b\ (1 - FCR)}{FCR}$$

$$\frac{FCOA}{FA} = \frac{W_b}{W_b + \dfrac{2W_b\ (1 - FCR)}{FCR}} = \frac{1}{1 + \dfrac{2(1 - FCR)}{FCR}}$$

FCR	$\frac{FCOA}{FA}$
.250	.1429
.375	.2308
.500	.3333
.675	.4545
.750	.6000
.875	.7778

Fiber Volume Ratio Analysis

In order for the thickness of Spacewind helical windings

to be the same at cross-over points and in between the cross-over areas, the fiber volume ratio "V_f (ratio of fiber volume to total of fiber plus resin volume) at the cross-over points will differ from the fiber volume ratio in between cross-over points.

The fiber volume ratio at and between cross-over points is,

$$t_{co} = \frac{2}{V_{fco}} \qquad \text{(two plies of windings)}$$

$$t_{bco} = \frac{1}{V_{fbco}} \qquad \text{(one ply of windings)}$$

Assuming there are no voids,

$$t_{co} = t_{bco} \text{ and } V_{fbco} = \frac{V_{fco}}{2}$$

As an example, assume the fiber volume ratio at the cross-over points $V_{fco} = .65$,

then between cross-over points the fiber volume ratio would be,

$$V_{fbco} = \frac{.65}{2} = .325$$

The desired fiber volume ratio assuming no resin bleed out for fiber coverage areas of 25 and 50% are,

<u>FCR = .25</u>

$$\frac{FCOA}{FA} = .1429$$

$$V_f = .1429 \times .65 + (1 - .1429)\ .325 = .3714$$

<u>FCR = .50</u>

$$\frac{FCOA}{FA} = .3333$$

$$V_f = .3333 \times .65 + (1 - .3333)\ .325) = .4333$$

APPENDIX B
DESIGN CALCULATIONS

DESIGN CALCULATIONS

Units one through six

Design Criteria

ID = 24.0 in.

L = 72.0 in.

Stiffness:

$EI_y = 2.6 \times 10^9$ lb-in^2

$EI_z = 2.6 \times 10^9$ lb-in^2

$GK = 1.2 \times 10^9$ lb-in^2

Limit Loads:

$M_x = 1.37 \times 10^5$ in-lb

$M_z = 3.87 \times 10^5$ in-lb

$S_z = 1.14 \times 10^3$ lb

Ultimate loads = 1.5 x limit loads

Construction -- 20% @ 90° (hoops) and 80% @ $\pm$ 24°

Fiber volume ratio = .50

Fiber coverage ratio (FCR) -- arbitrarily selected at .25 and .50.

Analysis

The material properties are based on computer analysis inputting the fiber and resin properties, fiber volume ratio, fiber orientation and fiber coverage ratio. Appendix E shows the composite material properties for the various materials. Note the helical winding angle was arrived at by an iterative process where the relation between the E and G of the composite satisfied the criteria stiffness.

Table 3 summarizes the calculation for units one through six. The equations used are shown in Appendix A and all stresses are for ultimate loads.

Property	S2-Glass/Epoxy		Kevlar 49/Epoxy		Thornel 300/Epoxy	
V_f, %	.50	.50	.50	.50	.50	.50
E_{11}, 10^6 psi	6.535	6.535	9.375	9.375	17.230	17.230
FCR, %	25	50	25	50	25	50
FACR (hel. only), %	43.75	75.00	43.75	75.00	43.75	75.00
FACR, %	57.81	87.50	57.81	87.50	57.81	87.50
E_x, 10^6 psi	.8536	1.7740	1.243	2.529	2.203	4.484
E_y, 10^6 psi	.3957	.9287	.5205	1.109	.9103	1.918
E_e, 10^6 psi	.5407	1.2192	.7337	1.5419	1.2883	2.6868
R_o, in.	12.5255	12.2613	12.3680	12.1851	12.2117	12.1054
t, in.	.5255	.2613	.3680	.1851	.2117	.1054
$\bar{R}$, in.	12.2628	12.1307	12.1840	12.0925	12.1059	12.0527
σ_{max}, psi	2338	4804	3381	6826	5955	12,067
τ_{max}, psi	498	1023	720	1450	1266	2563
σ_{cr}, psi	10,745	10,942	9774	9192	9019	7985*
F_{cu}, psi	13,760	28,025	4445	8988	13,691	27,759
$F_{cu\ 11}$	53,750	53,750	17,500	17,500	53,750	53,750
F_{su}, psi	3735	8306	1513	3256	3612	7877
L_{cr}, in	5.1258	3.6145	9.0040	6.3858	5.2827	3.7275
W_s, in.	3.8092	2.6861	6.6913	4.7456	3.9258	2.7701
W_b, in.	1.2697	2.6861	2.2304	4.7456	1.3086	2.7701

*$\sigma_{max} > \sigma_{cr}$, therefore, use sandwich wall construction , see page 35.

Table 3. Design Data, Units 1-6

CALCULATIONS FOR SANDWICH WALL CONSTRUCTION

$$t_c = .25 \text{ in.}$$

$$t_f = \frac{t}{2} = .0527 \text{ in.}$$

$$G_e = .750 \times 3000 = 2250 \text{ psi}$$

$$\sigma_{cr} = \frac{2250\ (.25 + .0527)}{2 \times .25 \times .0527} = 25{,}847 \text{ psi}$$

Units seven through ten

Design Criteria

$ID = 16.0$ in.

$L = 72.0$ in.

Stiffness:

$EI_y = 1.1 \times 10^9$ lb-in^2

$EI_z = 1.1 \times 10^9$ lb-in^2

$GK = 0.5 \times 10^9$ lb-in^2

Limit Loads:

$M_x = 1.2 \times 10^5$ in-lb

$M_z = 1.53 \times 10^5$ in-lb

$S_y = 2.922 \times 10^3$ lb

$S_z = 2.84 \times 10^2$ lb

Ultimate loads = 1.5 x limit loads

Construction -- 20% @ 90° (hoops) and 80% @ $\pm$ 24°

Fiber Volume Ratio -- .65 at cross-over areas and .325 between cross-over areas.

Average fiber volume ratio for .25 and .50 FCR are .3714 and .4333 respectively.

Fiber coverage ratio -- .25 and .50.

Analysis

The material properties are shown in Appendix F. Table 4 summarizes the calculations for units seven through ten.

Property	Kevlar 49/Epoxy	
V_f, %	32.5	32.5
E_{11}, 10^6 psi	6.492	6.492
F.C.R., %	25	50
FACR (hel. only), %	43.75	75.00
FACR, %	57.81	87.50
E_x, 10^6 psi	1.553	3.156
E_y, 10^6 psi	.5232	1.119
E_e, 10^6 psi	.7827	1.6522
R_o, in.	8.4081	8.2084
t, in.	.4081	.2084
$\bar{R}$, in.	8.2041	8.1042
σ_{max}, psi	2659	5337
τ_{max}, psi	1459	2919
σ_{cr}, psi	18,399	18,259
F_{cu}, psi	5558	11,241
F_{su}, psi	1837	3958
$F_{cu\ 11}$	11,375	11,375
L_{cr}, in.	6.2521	3.1927
W_s, in.	4.6462	2.3726
W_b, in.	1.5487	2.3726
ρ_c, lb/in^3	.0114	.0231

Table 4. Design Data, Units 7-10

APPENDIX C

END FITTING ANALYSIS

Frame

Internal member loads were solved by a computer program with the following assumptions:

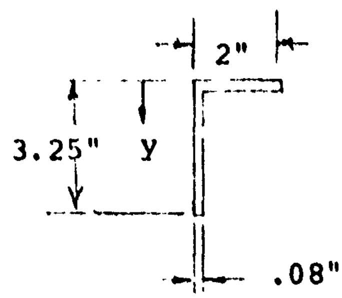
EI = Constant

Loads reacted in a $\frac{VQ}{I}$ or $\frac{Mx}{2A}$ distribution

The critical loads are summarized below.

B	V	P	M
55°	-20 lb	-2281 lb	-1038 in-lb
210°	26	1608	1137
225°	-1265	-3319	740
315°	-1265	-4094	739

Section properties of the frame (E-glass)



	A	y	Ay	Ay^2	Io
	.16	.04	.0064	.0003	--
	.26	1.625	.4225	.6866	.2289
Σ	.42		.4289	.6869	.2289

$$\bar{y} = \frac{.4289}{.42} = 1.02 \text{ in}$$

$$I = .2289 + .6869 - .42\ (1.02)^2 = .4788 \text{ in}^4$$

Maximum stresses are:

$$\sigma = \frac{4094}{.42} + \frac{739 \times 2.23}{.4788} = 13{,}189 \text{ psi}$$

$$\tau_{max} = \frac{3}{2} \times \frac{1265}{.42} = 4{,}518 \text{ psi}$$

Attachment

End Frame Limit Loads:

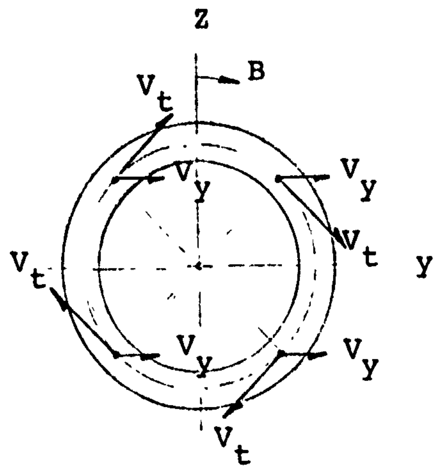
$M_x = 1.2 \times 10^5$ in-lb

$M_z = 1.53 \times 10^5$ in-lb

$S_y = 2922$ lbs

Ultimate load = limit load x 1.5

Bolt loads -- 4 bolts



$$P_x = \frac{153{,}000 \times 1.5}{2 \times 14 \cos 45°} = 11{,}591 \text{ lb}$$

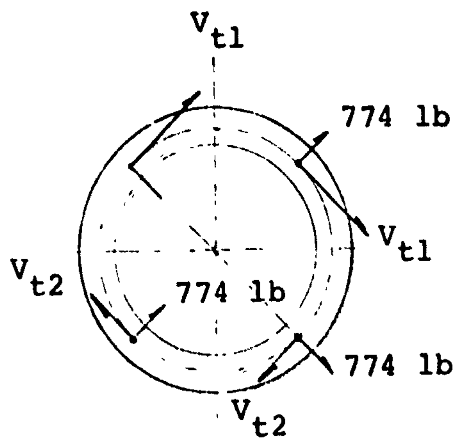
$$V_y = \frac{2922 \times 1.5}{4} = 1095 \text{ lb}$$

$$V_t = \frac{120{,}000 \times 1.5}{4 \times 7} = 6428 \text{ lb}$$

Resolving V_y to the tangential and radial force components

$$V_s = 1095 \cos 45° = 774 \text{ lb}$$

$$V_t = 1095 \sin 45° = 774 \text{ lb}$$



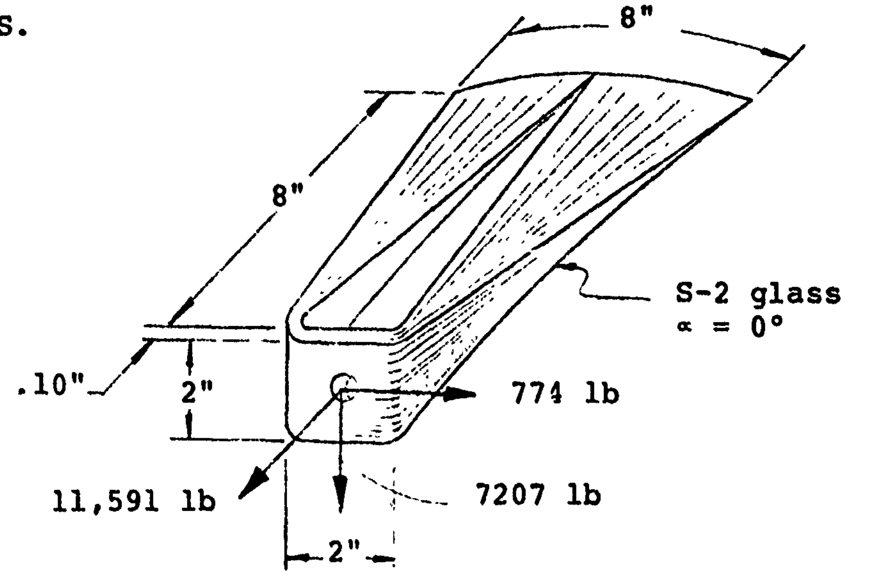
The combined tangential and radial forces are

$$V_{T1} = 6428 + 774 - 7202 \text{ lb}$$

$$V_{T2} = 6428 - 774 = 5654 \text{ lb}$$

Fitting

Use 1/2-20 UNF bolt
with 180,000 psi U.T.S.
socket head cap screw



Fiber stress

$$\sigma = \frac{11591}{2 \times 2 \times .1} = 28{,}977 \text{ psi}$$

Bond stress of broom

$$\tau = \frac{11591 \times 2}{8 \times 8 \times .4325} = 827 \text{ psi}$$

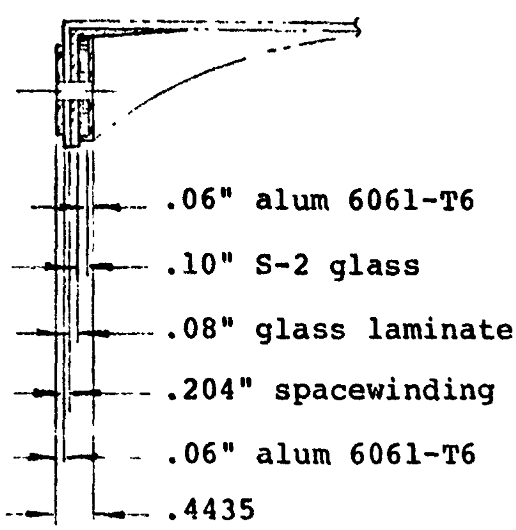
$$\text{Shear strength} = 180{,}000 \times .6 \times \pi\ (.25)^2 = 21{,}205 \text{ lb}$$

Bond stress of fitting end 2" x 2"

$$\tau = \frac{(774^2 + 7207^2)^{1/2}}{(2 \times 2) - (\pi \times 25^2)} = 1905 \text{ psi}$$

Bearing stress on metal insert

$$\sigma_{br} = \frac{(772^2 + 7207^2)^{1/2}}{(.5)\ (.4435)} = 16{,}343 \text{ psi}$$



APPENDIX D

MATERIAL PROPERTY COMPUTER PROGRAM

MATERIAL PROPERTY COMPUTER OUTPUT

NOMENCLATURE

AF	Fiber thermal expansion coefficient, in/in/F°
AFT	Fiber transverse thermal expansion coefficient, in/in/F°
AR	Resin thermal expansion coefficient, in/in/F°
AX	Composite thermal expansion coefficient in x-direction, in/in/F°
AY	Composite thermal expansion coefficient in y-direction, in/in/F°
EF	Fiber modulus, psi
EFT	Fiber transverse modulus, psi
ER	Resin modulus, psi
EX	Composite modulus in x-direction, psi
EY	Composite modulus in y-direction, psi
FCU	Fiber compressive strength, psi
FTU	Fiber tensile strength, psi
FXCU	Composite compressive strength in x-direction, psi
FXTU	Composite tensile strength in x-direction, psi
FXY	Composite shear strength, psi
FYCU	Composite compressive strength in y-direction, psi
FYTU	Composite tensile strength in y-direction, psi
GF	Fiber shear modulus, psi
GXY	Composite shear modulus, psi
RHO	Resin density, lb/in^3
TF	Fiber thickness, in
UF	Fiber Poisson's ratio
UXY	Composite Poisson's ratio
UYX	Composite Poisson's ratio

```
                PROGRAM SWPRGR(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)
000003          DIMENSION B11(10),B22(10),B33(10),B12(10),B13(10),B23(10),Q11L(10)
               1,Q22M(10),Q11N(10),Q12N(10),Q22N(10),Q66N(10),FTU(10),FCU(10),
               2Q12L(10),Q12M(10),     T(10),EF(10),EFT(10),GF(10),RHOF(10),UF(10)
               3,VF(10),HEAD(16),A(10),Q11S(10),Q12S(10),Q22S(10),Q66S(10),
               4AF(10),AFT(10),BT1(10),BT2(10),A1B(10),A2B(10),CK(10)
000003        1 READ(5,2)(HEAD(I),I=1,16)
000015        2 FORMAT(16A5)
000015          IF(EOF,5)110,4
000020        4 READ(5,5)RHOR,UR,ER,AR,K
000036        5 FORMAT(2F10.4,2E10.3,1I5)
000036          WRITE(6,7)HEAD
000044        7 FORMAT(1H1,16A5//)
000044          GR=ER/(2.*(1.+UR))
000050          WRITE(6,9)RHOR,UR,ER,GR,AR
000065        9 FORMAT(5X,16HRESIN PROPERTIES//6X,4HRHO=F6.4,5X,3HUR=F6.4,5X,3HER=
               1E10.3,5X,3HGR=E10.3,5X,3HAR=E10.3//)
000065          WRITE(6,10)
000071       10 FORMAT(5X,16HFIBER PROPERTIES//5X,127HNO.   ALPHA      TF       VF
               1    EF            EFT             GF             AF            AFT           UF
               2    RHOF          FTU           FCU        CK/)
               2CU/)
000071          RQ11=0.
000072          RQ12=0.
000072          RQ22=0.
000073          RQ66=0.
000074          RS11=0.
000075          RS12=0.
000076          RS22=0.
000077          RS66=0.
000100           TT=0.
000101          RHO=0.
000103          DO 20 I=1,K
000104          READ(5,12)A(I),T(I),RHOF(I),UF(I),VF(I),EF(I),EFT(I),GF(I),AF(I),A
               1FT(I),FTU(I),FCU(I),CK(I)
000141       12 FORMAT(5F10.4/5E10.3,2F10.4/1F10.4)
000141          WRITE(6,14)I,A(I),T(I),VF(I),EF(I),EFT(I),GF(I),AF(I),AFT(I),UF(I)
               1,RHOF(I),FTU(I),FCU(I),CK(I)
000201       14 FORMAT(I7,F6.2,2F8.4,5E12.3,2F8.4,2F10.0,1F6.4)
000201          FTU(I)=FTU(I)*VF(I)
000203          FCU(I)=FCU(I)*VF(I)
000205          TT=TT+T(I)
000207          T(I)=T(I)*CK(I)
000211          A=A(I)/57.29578
000213          S1=SIN(A)
000215          S2=S1**2
000216          S3=S1*S2
000220          S4=S2**2
000222          C1=COS(A)
000224          C2=C1**2
000225          C3=C1*C2
000227          C4=C2**2
000231          S2A=SIN(2.*A)
000235          C2A=COS(2.*A)
000241          IF(1.-VF(I))18,18,16
000245       16 CONTINUE
000245          ULT=UF(I)*VF(I)+UR*(1.-VF(I))
```

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

```
00252          C=SQRT(VF(I))
00254          EL=EF(I)*VF(I)+(1.-VF(I))*ER
00262          EC=EFT(I)
00263          ET=((C*EC+(1.-C)*ER)*ER)/(C*ER+(1.-2.*UR**2)*(1.-C)*(C*EC+(1.-C)*
              1ER))*CK(I)
00302          UTL=ULT*ET/EL
00305          U=1.-ULT*UTL
00310          GLT=GR*(GF(I)*C+GR*(1.-C))/((1.-C)*(GF(I)*C+GR*(1.-C))+GR*C)*CK(I)
00324          GO TO 19
00324       18 CONTINUE
00324          EL=EF(I)
00326          ET=EF(I)
00327          U=1.-UF(I)**2
00332          GLT=GF(I)
00334       19 B11(I)=1./U*(EL*C4+ET*S4+(2.*EL*UTL+4.*U*GLT)*S2*C2)
00350          B22(I)=1./U*(ET*C4+EL*S4+(2.*EL*UTL+4.*U*GLT)*S2*C2)
00365          B33(I)=1./U*((EL+ET-2.*EL*UTL)*S2*C2+U*GLT*(C2-S2)**2)
00401          B12(I)=1./U*((EL+ET-4.*U*GLT)*S2*C2+EL*UTL*(C4+S4))
00416          B13(I)=1./U*((ET-EL*UTL-2.*U*GLT)*S3*C1-(EL-EL*UTL-2.*U*GLT)*S1*C3
              C)
00437          B23(I)=1./U*((ET-EL*UTL-2.*U*GLT)*S1*C3-(EL-EL*UTL-2.*U*GLT)*S3*C1
              C)
00460          E1=EL/(C4+EL*S4/ET+.25*(EL/GLT-2.*ULT)*S2A*S2A)
00473          E2=EL/(S4+EL*C4/ET+.25*(EL/GLT-2.*ULT)*S2A*S2A)
00505          G12=EL/(1.+2.*ULT+EL/ET-(1.+2.*ULT+EL/ET-EL/GLT)*C2A*C2A)
00524          U12=E1/EL*(ULT-.25*(1.+2.*ULT+EL/ET-EL/GLT)*S2A*S2A)
00537          U21=U12*E2/E1
00541          B1=S2A*(2.*ULT+EL/ET-.5*EL/GLT-C2*(1.+2.*ULT+EL/ET-EL/GLT))
00556          B2=S2A*(2.*ULT+EL/ET-.5*EL/GLT-S2*(1.+2.*ULT+EL/ET-EL/GLT))
00573          E1B=EL/(EL/E1-B1*B1*G12/EL)
00601          E2B=EL/(EL/E2-B2*B2*G12/EL)
00606          U21B=E2B/EL*(U21*EL/E2+B1*B2*G12/EL)
00615          U12B=E1B/EL*(U12*EL/E1+B1*B2*G12/EL)
00623          G12B=EL*(1.-U12*U21)/(EL*(1.-U12*U21)/G12-B1*E1/EL*(B1+U21*B2)-B2*
              1E2/EL*(B2+U12*B1))
00646          AL=(AR*(1.-VF(I))*ER+AF(I)*VF(I)*EF(I))/EL
00656          B=SQRT(VF(I)/3.1415926)
00663          AO=AR*(1.-2.*B)+2.*AFT(I)*B-UR*(AFT(I)-AR)*(1.-2.*B)
00677          EO=ER*EFT(I)/(EFT(I)*(1.-2.*B)+2.*ER*B)
00710          AT=(AO*EO*B+AR*ER*(1.-B))/ET
00717          A1=AL*C2+AT*S2
00722          A2=AL*S2+AT*C2
00726          A12=2.*(AT-AL)*S1*C1
00731          BT1(I)=E1B*T(I)/(1.-U12*U21)
00737          BT2(I)=E2B*T(I)/(1.-U12*U21)
00744          A1B(I)=A1-A12*B1*G12/EL
00751          A2B(I)=A2-A12*B2*G12/EL
         C     STRENGTH CALCULATIONS
00757          ET=0.
00757          ULT=0.
00760          UTL=0.
00761          PSI=1.
00763          U1=1./(8.*PSI)*(EL+ET+UTL*EL+ULT*ET)
00771          U2=1./(2.*PSI)*(PSI*GLT-.5*(UTL*EL+ULT*ET))
01001          U3=1./(2.*PSI)*(EL-ET)
01006          U4=1./(8.*PSI)*(EL+ET-(UTL*EL+ULT*ET)-4.*PSI*GLT)
01021          Q11C(I)=3.*U1+U2+U3+U4
01027          Q12C(I)=U1-U2-U4
```

```
001031        Q12M(I)=U1-U2-U4
001033        Q22M(I)=3.*U1+U2+U3+U4
001040        Q11N(I)=3.*U1+U2+U3*COS(2.*A)+U4*COS(4.*A)
001057        Q12N(I)=U1-U2-U4*COS(4.*A)
001070        Q22N(I)=3.*U1+U2-U3*COS(2.*A     )+U4*COS(4.*A)
001106        Q66N(I)=U1+U2-U4*COS(4.*A)
001117        A=.785398-A
001120        Q11S(I)=3.*U1+U2+U3*COS(2.*A)+U4*COS(4.*A)
001137        Q12S(I)=U1-U2-U4*COS(4.*A)
001150        Q22S(I)=3.*U1+U2-U3*COS(2.*A     )+U4*COS(4.*A)
001166        Q66S(I)=U1+U2-U4*COS(4.*A)
001177     20 CONTINUE
001201        RHO=RHO/TT
001203        BB11=0.
001203        BB12=0.
001204        BB22=0.
001205        BB33=0.
001206        SBA1=0.
001207        SBA2=0.
001210        SB1=0.
001211        SB2=0.
001213        DO 30 I=1,K
001214        RHO=(VF(I)*RHOF(I)+(1.-VF(I))*RHOR)*T(I)/TT+RHO
001225        BB11=BB11+B11(I)*T(I)
001227        BB12=BB12+B12(I)*T(I)
001232        BB22=BB22+B22(I)*T(I)
001235        BB33=BB33+B33(I)*T(I)
001240        RQ11=Q11N(I)*T(I)/TT+RQ11
001244        RQ12=Q12N(I)*T(I)/TT+RQ12
001247        RQ22=Q22N(I)*T(I)/TT+RQ22
001252        RQ66=Q66N(I)*T(I)/TT+RQ66
001255        RS11=Q11S(I)*T(I)/TT+RS11
001260        RS12=Q12S(I)*T(I)/TT+RS12
001263        RS22=Q22S(I)*T(I)/TT+RS22
001266        RS66=Q66S(I)*T(I)/TT+RS66
001271        SBA1=SBA1+BT1(I)*A1B(I)
001274        SBA2=SBA2+BT2(I)*A2B(I)
001277        SB1=SB1+BT1(I)
001301        SB2=SB2+BT2(I)
001303     30 CONTINUE
001305        BX=BB11-BB12**2/BB22
001310        BY=BB22-BB12**2/BB11
001314        UXY=BB12/BB22
001315        UYX=BB12/BB11
001316        EX=BX/TT
001320        EY=BY/TT
001321        BXY=BB33
001323        GXY=BXY/TT
001324        AX =SBA1/SB1
001326        AY =SBA2/SB2
001331     21 WRITE(6,22)EX,UXY,EY,UYX,GXY,RHO,AX,AY
001355     22 FORMAT(//5X,20HCOMPOSITE PROPERTIES//6X,3HEX=E11.3,5X,4HUXY=F6.4/6
             1X,3HEY=E11.3,5X,4HUYX=F6.4/6X,4HGXY=E10.3,5X,4HRHO=F6.4/
             26X,3HAX=E11.3/6X,3HAY=E11.3/                              /5X,54HNO.
             3        FXTU        FYTU        FXCU        FYCU        FXY/)
001355        DO 40 I=1,K
001357        FXTU=FTU(I)*(RQ11*RQ22-RQ12*RQ12)/(Q11L(I)*RQ22-Q12L(I)*RQ12)
001367        FYTU=FTU(I)*(RQ11*RQ22-RQ12*RQ12)/(Q22M(I)*RQ11-Q12M(I)*RQ12)
```

```
001376          FXCU=FCU(I)*(RQ11*RQ22-RQ12*RQ12)/(Q11L(I)*RQ22-Q12L(I)*RQ12)
001406          FYCU=FCU(I)*(RQ11*RQ22-RQ12*RQ12)/(Q22M(I)*RQ11-Q12M(I)*RQ12)
001415          FSTU=FTU(I)*(RS11*RS22-RS12*RS12)/(Q11L(I)*RS22-Q12L(I)*RS12)
001425          FSCU=FCU(I)*(RS11*RS22-RS12*RS12)/(Q11L(I)*RS22-Q12L(I)*RS12)
001435          FXY   =FSTU/((1.+(FSTU/FSCU)**2+FSTU/FSCU)**.5)/2.
001446       24 WRITE(6,26)I,FXTU,FYTU,FXCU,FYCU,FXY
001466       26 FORMAT(I7,3X,5F10.0)
001466       40 CONTINUE
001471          GO TO 1
001471      110 STOP
001473          END
```

APPENDIX E

MATERIAL PROPERTIES, UNITS 1-6

S-GLASS/EPOXY

RESIN PROPERTIES

RHO= .0412 UR= .3500 ER= 4.700E+05 GR= 1.741E+05 AR= 4.000E-0

FIBER PROPERTIES

NO.	ALPHA	TF	VF	EF	EFT	GF	AF	
1	90.00	.2000	.5000	1.260E+07	1.260E+07	4.000E+05	2.200E-06	2
2	24.00	.8000	.5000	1.260E+07	1.260E+07	4.000E+05	2.200E-06	2

COMPOSITE PROPERTIES

EX= 8.536E+05	UXY= .4794
EY= 3.957E+05	UYX= .2222
GXY= 1.961E+05	RHO= .0164
AX= -3.826E-06	
AY= 1.533E-05	

NO.	FXTU	FYTU	FXCU	FYCU	FXY
1	20800	8382	13760	5545	3735
2	20800	8382	13760	5545	3735

4.3529

1.741E+05 AR= 4.000E-05

GF	AF	AFT	UF	RHOF	FTU	FCU	CK
4.000E+05	2.200E-06	2.20[illegible]E-06	.2200	.0900	325000	215000	.2500
4.000E+05	2.200E-06	2.20[illegible]E-06	.2200	.0900	325000	215000	.2500

FXY

3735
3735

2

S-GLASS/EPOXY

RESIN PROPERTIES

RHO= .0412 UR= .3500 ER= 4.700E+05 GR= 1.741E+05 AR= 4.000E-05

FIBER PROPERTIES

NO.	ALPHA	TF	VF	EF	EFT	GF	AF	AFT
1	90.00	.2000	.5000	1.260E+07	1.260E+07	4.000E+05	2.200E-06	2.20
2	24.00	.8000	.5000	1.260E+07	1.260E+07	4.000E+05	2.200E-06	2.20

COMPOSITE PROPERTIES

EX=	1.774E+06	UXY=	.4667
EY=	9.287E+05	UYX=	.2444
GXY=	4.236E+05	RHO=	.0328
AX=	7.622E-07		
AY=	1.194E-05		

NO.	FXTU	FYTU	FXCU	FYCU	FXY
1	42364	17271	28025	11426	8306
2	42364	17271	28025	11426	8306

4.1879

.741E+05 AR= 4.000E-05

GF	AF	AFT	UF	PHOF	FTU	FCU	CK
4.000E+05	2.200E-06	2.200E-06	.2200	.0900	325000	215000	.5000
4.000E+05	2.200E-06	2.200E-06	.2200	.0900	325000	215000	.5000

Y

06
06

2

KEVLAR 49/EPOXY

RESIN PROPERTIES

RHO= .0412 UR= .3500 ER= 4.700E+05 GR= 1.741E+05 AR= 4.000E-05

FIBER PROPERTIES

NO.	ALPHA	TF	VF	EF	EFT	GF	AF	AFT
1	90.00	.2000	.5000	1.900E+07	1.000E+06	3.000E+05	-3.440E-06	3.000
2	24.00	.8000	.5000	1.900E+07	1.000E+06	3.000E+05	-3.440E-06	3.000

COMPOSITE PROPERTIES

EX= 1.243E+06 UXY= .4833
EY= 5.205E+05 UYX= .2023
GXY= 2.795E+05 RHO= .0117
AX= -2.060E-05
AY= 5.869E-06

NO.	FXTU	FYTU	FXCU	FYCU	FXY
1	24129	9676	4445	1782	1513
2	24129	9676	4445	1782	1513

41E+05 AR= 4.[illegible]00E-05

GF	AF	AFT	UF	RHOF	FTU	FCU	CK
.000E+05	-3.440E-06	3.000E-05	.2200	.0524	380000	70000	.2500
.000E+05	-3.440E-06	3.000E-05	.2200	.0524	380000	70000	.2500

KEVLAR 49/EPOXY

RESIN PROPERTIES

RHO= .0412   UR= .3500   ER= 4.700E+05   GR= 1.741E+05   AR= 4.000E-05

FIBER PROPERTIES

NO.	ALPHA	TF	VF	EF	EFT	GF	AF	AFT
1	90.00	.2000	.5000	1.900E+07	1.000E+06	3.000E+05	-3.440E-06	3.00[illegible]
2	24.00	.8000	.5000	1.900E+07	1.000E+06	3.000E+05	-3.440E-06	3.00[illegible]

COMPOSITE PROPERTIES

EX= 2.529E+06	UXY= .4707
EY= 1.109E+06	UYX= .2063
GXY= 5.804E+05	RHO= .0234
AX= -1.103E-05	
AY= 5.396E-06	

NO.	FXTU	FYTU	FXCU	FYCU	FXY
1	48792	19702	8988	3629	3256
2	48792	19702	8988	3629	3256

4.35.73

.741E+05   AR= 4.000E-05

GF	AF	AFT	UF	RHOF	FTU	FCU	CK
3.000E+05	-3.440E-06	3.000E-05	.2200	.0524	380000	70000	.5000
3.000E+05	-3.440E-06	3.000E-05	.2200	.0524	380000	70000	.5000

Y

56

56

2

THORNEL 300/EPOXY

RESIN PROPERTIES

RHO= .0412 UR= .3500 ER= 4.700E+05 GR= 1.741E+05 AR= 4.000E-05

FIBER PROPERTIES

NO.	ALPHA	TF	VF	EF	EFT	GF	AF
1	90.00	.2000	.5000	3.400E+07	1.300E+06	3.500E+06	-2.400E-07
2	24.00	.8000	.5000	3.400E+07	1.300E+06	3.500E+06	-2.400E-07

COMPOSITE PROPERTIES

EX= 2.203E+06 UXY= .4781
EY= 9.103E+05 UYX= .1975
GXY= 4.968E+05 RHO= .0131
AX= -8.847E-06
AY= 3.277E-06

NO.	FXTU	FYTU	FXCU	FYCU	FXY
1	20696	8314	13691	5500	3612
2	20696	8314	13691	5500	3612

4.4344

.741E+05 AR= 4.000E-05

GF	AF	AFT	UF	RHOF	FTU	FCU	CK
3.500E+06	-2.400E-07	2.960E-06	.2200	.0636	325000	215000	.2500
3.500E+06	-2.400E-07	2.960E-06	.2200	.0636	325000	215000	.2500

Y

512
512

ABLE

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

THORNEL 300/EPOXY

RESIN PROPERTIES

RHO= .0412 UR= .3500 ER= 4.700E+05 GR= 1.741E+05 AR= 4.000E-05

FIBER PROPERTIES

NO.	ALPHA	TF	VF	EF	EFT	GF	AF	A
1	90.00	.2000	.5000	3.400E+07	1.300E+06	3.500E+06	-2.400E-07	2.
2	24.00	.8000	.5000	3.400E+07	1.300E+06	3.500E+06	-2.400E-07	2.

COMPOSITE PROPERTIES

EX= 4.484E+06 UXY= .4603
EY= 1.918E+06 UYX= .1969
GXY= 1.035E+06 RHO= .0262
AX= -3.869E-06
AY= 3.107E-06

NO.	FXTU	FYTU	FXCU	FYCU	FXY
1	41962	17003	27759	11248	7877
2	41962	17003	27759	11248	7877

4.3324

.741F+05 AR= 4.[illegible]E-05

GF	AF	AFT	UF	RHOF	FTU	FCU	CK
.500E+06	-2.400E-[illegible]	2.96[illegible]E-06	.220[illegible]	.0636	325[illegible]	21500[illegible]	.5[illegible]
3.500E+06	-2.400E-[illegible]	2.96[illegible]E-[illegible]6	.220[illegible]	.0636	325[illegible]	215000	.5[illegible]

APPENDIX F

MATERIALS PROPERTIES

UNITS 7-10

*FCR .25 3

KEVLAR 49/EPOXY

RESIN PROPERTIES

RHO= .0412 UR= .3500 ER= 4.700E+05 GR= 1.741E+05 AR= 4.000E-05

FIBER PROPERTIES

NO.	ALPHA	TF	VF	EF	EFT	GF	AF	AFT
1	90.00	.2000	.5000	1.900E+07	1.000E+06	3.000E+05	-3.440E-06	3.000
2	24.00	.8000	.6500	1.900E+07	1.000E+06	3.000E+05	-3.440E-06	3.000

COMPOSITE PROPERTIES

EX= 1.553E+06 UXY= .5977
EY= 5.232E+05 UYX= .2013
GXY= 3.571E+05 RHO= .0120
AX= -2.124E-05
AY= 6.293E-06

NO.	FXTU	FYTU	FXCU	FYCU	FXY
1	30173	9691	5558	1785	1837
2	30513	9800	5621	1805	1858

741E+05 AR= 4.000E-05

GF	AF	AFT	UF	RHCF	FTU	FCU	CK*
.000E+05	-3.440E-06	3.000E-05	.2200	.0524	380000	70000	.2500
.000E+05	-3.440E-06	3.000E-05	.2200	.0524	380000	70000	.2500

7
8

*FCR 50?

KEVLAR 49/EPOXY

RESIN PROPERTIES

RHO= .0412 UR= .3500 ER= 4.700E+05 GR= 1.741E+05 AR= 4.000E-05

FIBER PROPERTIES

NO.	ALPHA	TF	VF	EF	EFT	GF	AF	AFT
1	90.00	.2000	.5000	1.900E+07	1.000E+06	3.000E+05	-3.440E-06	3.00
2	24.00	.8000	.6500	1.900E+07	1.000E+06	3.000E+05	-3.440E-06	3.00

COMPOSITE PROPERTIES

EX= 3.156E+06	UXY= .5762
EY= 1.119E+06	UYX= .2044
GXY= 7.371E+05	RHO= .0241
AX= -1.168E-05	
AY= 5.739E-06	

NO.	FXTU	FYTU	FXCU	FYCU	FXY
1	61024	19760	11241	3640	3958
2	61711	19983	11369	3681	4003

.741E+05 AR= 4.000E-05

GF	AF	AFT	UF	RHOF	FTU	FCU	CK*
3.000E+05	-3.440E-06	3.000E-05	.2200	.0524	380000	70000	.5000
3.000E+05	-3.440E-06	3.000E-05	.2200	.0524	380000	70000	.5000

Y

58
03

KEVLAR 49/EPOXY

RESIN PROPERTIES

RHO= .0412 UR= .3500 ER= 4.760E+05 GR= 1.741E+05 AR= 4.000E-05

FIBER PROPERTIES

NO.	ALPHA	TF	VF	EF	EFT	GF	AF	AFT
1	90.00	.2000	.5000	1.900E+07	1.000E+06	3.000E+05	-3.440E-06	3.000E-0
2	24.00	.8000	.3714	1.900E+07	1.000E+06	3.000E+05	-3.440E-06	3.000E-0

COMPOSITE PROPERTIES

EX= 9.650E+05 UXY= .3793
EY= 5.164E+05 UYX= .2037
GXY= 2.131E+05 RHO= .0114
AX= -1.993E-05
AY= 5.586E-06

NO.	FXTU	FYTU	FXCU	FYCU	FXY
1	18681	9665	3441	1763	1207
2	18374	9590	3385	1751	1187

741E+05 AR= 4.000E-05

GF	AF	AFT	UF	RHOF	FTU	FCU	CK
.000E+05	-3.440E-06	3.000E-05	.2200	.0524	380000	70000	.2500
.000E+05	-3.440E-06	3.000E-05	.2200	.0524	380000	70000	.2500

7
7

KEVLAR 49/EPOXY

RESIN PROPERTIES

RHO= .0412 UR= .3500 ER= 4.700E+05 GR= 1.741E+05 AR= 4.000E-05

FIBER PROPERTIES

NO.	ALPHA	TF	VF	EF	EFT	GF	AF	AFT
1	90.00	.2000	.5000	1.900E+07	1.000E+06	3.000E+05	-3.440E-06	3.00
2	24.00	.8000	.4333	1.900E+07	1.000E+06	3.000E+05	-3.440E-06	3.00

COMPOSITE PROPERTIES

EX= 2.241E+06 UXY= .4213
EY= 1.104E+06 UYX= .2076
GXY= 5.1.8E+05 RHO= .0231
AX= -1.059E-05
AY= 5.258E-06

NO.	FXTU	FYTU	FXCU	FYCU	FXY
1	43148	19677	7948	3625	2923
2	42830	19532	7690	3598	2902

41E+05 AR= 4.000E-05

GF	AF	AFT	UF	RHOF	FTU	FCU	CK
000E+05	-3.440E-06	3.000E-05	.2200	.0524	380000	70000	.5000
000E+05	-3.440E-06	3.000E-05	.2200	.0524	380000	70000	.5000

2

KEVLAR 49/EPOXY

FIBER PROPERTIES

VF = .3250
WF = .3793
RHOF= .0524
FTU = 325000.0
FCU = 70000.0
UF = .2200

EF = 1.900E+07
EFT= 1.000E+06
GF = 3.000E+05
AF =-2.000E-06
AFT= 3.300E-05

RESIN PROPERTIES

VR = .6750
WR = .6202
RHOR= .0412
FSU = 8000.0

ER = 4.700E+05
AR = 4.000E-05
UR = .3500

COMPOS

RHO=
FTU=
FCU=
FSU=

ALPHA	EX	EY	GXY	UXY	UYX	FXTU	FYTU	F
.00	6.492E+06	6.998E+05	2.188E+05	.3177	.0332	R	-.0	227
1.00	6.488E+06	6.997E+05	2.107E+05	.3134	.0335	105375.5	4.1	227
2.00	6.473E+06	6.992E+05	2.161E+05	.3181	.0344	104633.3	16.5	226
3.00	6.449E+06	6.983E+05	2.252E+05	.3311	.0358	103417.4	37.3	226
4.00	6.416E+06	6.971E+05	2.379E+05	.3491	.0379	101757.9	66.4	225
5.00	6.372E+06	6.956E+05	2.543E+05	.3721	.0406	99694.3	103.9	223
6.00	6.318E+06	6.938E+05	2.736E+05	.3999	.0439	97273.5	149.9	222
7.00	6.253E+06	6.916E+05	2.966E+05	.4323	.0478	94546.9	204.5	220
8.00	6.176E+06	6.892E+05	3.227E+05	.4692	.0523	91568.4	267.8	217
9.00	6.089E+06	6.864E+05	3.520E+05	.5101	.0575	88391.7	339.8	214
10.00	5.989E+06	6.833E+05	3.842E+05	.5549	.0633	85068.9	420.9	211
11.00	5.878E+06	6.799E+05	4.193E+05	.6029	.0697	81648.5	511.0	20
12.00	5.754E+06	6.763E+05	4.568E+05	.6530	.0768	78174.7	610.5	20
13.00	5.619E+06	6.723E+05	4.969E+05	.7071	.0846	74686.3	719.5	19
14.00	5.469E+06	6.682E+05	5.392E+05	.7619	.0931	71217.0	838.2	19
15.00	5.308E+06	6.638E+05	5.836E+05	.8178	.1023	67795.0	966.8	18
16.00	5.136E+06	6.591E+05	6.298E+05	.8736	.1121	64443.7	1105.8	18
17.00	4.953E+06	6.543E+05	6.776E+05	.9292	.1228	61180.1	1255.8	17
18.00	4.759E+06	6.494E+05	7.267E+05	.9832	.1341	58019.3	1415.8	17
19.00	4.558E+06	6.442E+05	7.770E+05	1.0354	.1463	54971.1	1587.	16
20.00	4.349E+06	6.390E+05	8.282E+05	1.0837	.1593	52042.3	1770.3	15
21.00	4.134E+06	6.337E+05	8.800E+05	1.1285	.1730	49237.2	1965.4	14
22.00	3.915E+06	6.284E+05	9.322E+05	1.1689	.1876	46557.7	2172.9	14
23.00	3.694E+06	6.232E+05	9.845E+05	1.2041	.2031	44003.7	2393.3	13
24.00	3.474E+06	6.180E+05	1.037E+06	1.2337	.2195	41574.0	2627.1	12
25.00	3.255E+06	6.129E+05	1.089E+06	1.2573	.2368	39266.0	2874.8	11
26.00	3.041E+06	6.081E+05	1.140E+06	1.2747	.2550	37076.3	3137.0	11
27.00	2.831E+06	6.035E+05	1.190E+06	1.2859	.2742	35001.0	3414.4	10
28.00	2.629E+06	5.994E+05	1.239E+06	1.2908	.2944	33035.7	3707.6	9
29.00	2.435E+06	5.957E+05	1.287E+06	1.2896	.3156	31175.7	4017.	8
30.00	2.250E+06	5.926E+05	1.333E+06	1.2829	.3378	29416.1	4344.	8
31.00	2.077E+06	5.903E+05	1.377E+06	1.2707	.3611	27752.2	4689.	7
32.00	1.914E+06	5.889E+05	1.420E+06	1.2535	.3855	26173.9	5052.9	6
33.00	1.763E+06	5.883E+05	1.460E+06	1.2320	.4111	24691.6	5436.7	6
34.00	1.623E+06	5.891E+05	1.497E+06	1.2065	.4378	23285.7	5841.4	5
35.00	1.495E+06	5.912E+05	1.532E+06	1.1776	.4655	21955.5	6268.1	5
36.00	1.379E+06	5.950E+05	1.565E+06	1.1458	.4946	20699.9	6718.	4
37.00	1.273E+06	6.007E+05	1.594E+06	1.1117	.5247	19511.7	7192.1	
38.00	1.178E+06	6.085E+05	1.620E+06	1.0758	.5560	18368.0	7692.0	
39.00	1.092E+06	6.188E+05	1.643E+06	1.0384	.5884	17325.1	8218.9	
40.00	1.016E+06	6.319E+05	1.663E+06	1.0000	.6219	16319.4	8774.5	
41.00	9.488E+05	6.482E+05	1.679E+06	.9610	.6565	15367.6	9360.2	
42.00	8.895E+05	6.690E+05	1.691E+06	.9216	.6921	14466.8	9977.9	
43.00	8.375E+05	6.919E+05	1.700E+06	.8822	.7287	13613.8	10629.4	
44.00	7.925E+05	7.203E+05	1.706E+06	.8430	.7662	12805.9	11316.7	
45.00	7.536E+05	7.536E+05	1.709E+06	.8043	.8043	12040.7	12041.3	

TIES

ER = 4.730E+05
AR = 4.000E-05
UR = .3500

.0

COMPOSITE PROPERTIES

RHO= .0448
FTU= 105625.0
FCU= 22750.0
FSU= 8000.0

UVX	FXTU	FYTU	FXCU	FYCU	FXY	AX	AY
.0332	[illegible]	-.0	22750.0	2430.0	1198.2	5.237E-08	3.014E-05
.0335	105375.5	4.1	22735.4	2429.4	1254.9	4.438E-08	3.014E-05
.0344	104633.3	16.5	22691.3	2427.7	1328.9	2.042E-08	3.013E-05
.0358	103417.4	37.3	22617.3	2424.9	1412.9	-1.954E-08	3.012E-05
.0379	101757.9	66.4	22512.6	2421.0	1508.1	-7.549E-08	3.010E-05
.0406	99694.3	103.9	22376.1	2416.0	1615.3	-1.475E-07	3.008E-05
.0439	97273.5	149.9	22216.4	2409.9	1735.4	-2.355E-07	3.005E-05
.0478	94546.9	204.5	22022.[illegible]	2402.7	1869.3	-3.395E-07	3.001E-05
.0523	91568.4	267.9	21761.1	2394.5	2017.9	-4.595E-07	2.997E-05
.0575	88391.7	339.9	21482.1	2385.2	2181.7	-5.953E-07	2.992E-05
.0633	85068.9	421.9	21153.1	2374.9	2351.4	-7.473E-07	2.985E-05
.0697	81648.5	511.0	20812.6	2363.7	2557.3	-9.159E-07	2.978E-05
.0768	78174.7	613.5	20399.[illegible]	2351.6	2769.6	-1.103E-06	2.970E-05
.0846	74686.3	719.5	19951.7	2338.5	2998.3	-1.299E-06	2.961E-05
.0931	71217.0	838.[illegible]	19459.9	2324.7	3243.0	-1.514E-06	2.950E-05
.1027	67795.0	966.8	18973.9	2310.0	3503.3	-1.743E-06	2.937E-05
.1121	64443.7	1105.8	18344.5	2294.7	3778.2	-1.987E-06	2.923E-05
.1228	61180.1	1255.5	17723.6	2278.8	4066.5	-2.244E-06	2.906E-05
.1341	58019.3	1415.5	17064.[illegible]	2262.3	4365.8	-2.514E-06	2.888E-05
.1467	54971.1	1587.[illegible]	16389.3	2245.4	4677.3	-2.795E-06	2.866E-05
.1593	52042.3	1770.[illegible]	15684.2	2228.1	4995.1	-3.087E-06	2.842E-05
.173	49237.2	1965.4	14894.3	2210.7	5320.9	-3.386E-06	2.815E-05
.1876	46557.7	2172.9	14126.0	2193.3	5649.4	-3.692E-06	2.784E-05
.2031	44003.7	2393.3	13346.0	2176.[illegible]	5979.1	-4.001E-06	2.749E-05
.2195	41574.0	2627.1	12561.7	2159.[illegible]	6307.7	-4.309E-06	2.709E-05
.2368	39266.0	2874.8	11780.4	2142.6	6632.4	-4.613E-06	2.665E-05
.255	37076.3	3137.0	11009.2	2127.[illegible]	6951.1	-4.903E-06	2.614E-05
.2742	35001.0	3414.4	10255.[illegible]	2112.5	7261.4	-5.188E-06	2.558E-05
.2944	33035.7	3707.5	9524.[illegible]	2098.3	7561.3	-5.445E-06	2.495E-05
.3156	31175.7	4017.[illegible]	8821.7	2087.9	7848.9	-5.675E-06	2.425E-05
.3378	29416.1	4344.[illegible]	8152.6	2078.7	8122.5	-5.867E-06	2.347E-05
.3611	27752.2	4689.[illegible]	752[illegible].3	2072.1	8383.8	-6.011E-06	2.261E-05
.3856	26173.9	5052.9	6927.3	2068.6	8622.8	-6.097E-06	2.166E-05
.4111	24691.6	5436.7	6375.5	2068.7	8847.5	-6.113E-06	2.062E-05
.4378	23285.7	5841.4	5935.5	2073.3	9054.3	-6.045E-06	1.948E-05
.4656	21955.6	6268.1	5397.4	2082.8	9242.9	-5.884E-06	1.825E-05
.4946	20699.0	6718.[illegible]	4970.6	2098.2	9413.0	-5.614E-06	1.693E-05
.5247	19511.7	7192.1	4593.7	2120.4	9564.6	-5.225E-06	1.552E-05
.556	18[illegible]68.[illegible]	7692.[illegible]	4275.[illegible]	2150.3	9697.7	-4.705E-06	1.404E-05
.5884	17325.1	8218.9	3903.1	2189.1	9812.5	-4.047E-06	1.248E-05
.6219	16319.4	8774.5	3545.1	2237.9	9909.0	-3.245E-06	1.088E-05
.6565	15367.6	9356.2	3309.1	2298.2	9987.7	-2.298E-06	9.239E-06
.6921	14466.8	9977.3	3192.4	2371.4	10048.6	-1.203E-06	7.589E-06
.7287	13613.8	10629.4	2932.8	2459.2	10092.0	1.632E-08	5.952E-06
.7662	12805.0	11316.7	2827.9	2563.3	10117.9	1.363E-06	4.352E-06
.8043	12040.7	12041.7	2555.4	2685.6	10126.5	2.815E-06	2.814E-06

2

KEVLAR 49/EPOXY

FIBER PROPERTIES

VF = .6500
WF = .7026
RHOF= .0524
FTU = 325000.0
FCU = 70000.0
UF = .2200

EF = 1.900E+07
EFT= 1.000E+06
GF = 3.000E+05
AF =-2.000E-06
AFT= 3.300E-05

RESIN PROPERTIES

VR = .3500
WR = .2974
RHOR= .0412
FSU = 8000.0

ER = 4.700E+05
AR = 4.000E-05
UR = .3500

COMPO

RHO=
FTU=
FCU=
FSU=

ALPHA	EX	EY	GXY	UXY	UYX	FXTU	FYTU	F
.00	1.251E+07	8.266E+05	2.476E+05	.2655	.0175	211250.0	.9	455
1.00	1.251E+07	8.264E+05	2.513E+05	.2699	.0178	210439.9	5.1	45
2.00	1.248E+07	8.258E+05	2.622E+05	.2831	.0187	208044.5	27.4	45
3.00	1.243E+07	8.248E+05	2.803E+05	.3051	.0202	204164.9	45.9	45
4.00	1.236E+07	8.234E+05	3.056E+05	.3356	.0224	198957.9	81.7	45
5.00	1.228E+07	8.216E+05	3.379E+05	.3746	.0251	192621.2	127.9	447
6.00	1.217E+07	8.194E+05	3.770E+05	.4218	.0284	185375.5	184.5	44
7.00	1.203E+07	8.169E+05	4.228E+05	.4769	.0324	177448.3	251.8	43
8.00	1.188E+07	8.14[illegible]E+05	4.750E+05	.5393	.037[illegible]	169058.8	329.7	43
9.00	1.169E+07	8.107E+05	5.334E+05	.6[illegible]85	.0422	161467.7	418.5	42
10.00	1.148E+07	8.070E+05	5.977E+05	.6838	.0481	151668.3	518.6	42
11.00	1.124E+07	8.030E+05	6.676E+05	.7643	.0546	142987.4	629.9	41
12.00	1.096E+07	7.987E+05	7.423E+05	.8490	.0619	134480.4	752.7	40
13.00	1.056E+07	7.940E+05	8.228E+05	.9366	.0698	126235.7	887.4	39
14.00	1.032E+07	7.89[illegible]E+05	9.073E+05	1.0258	.0784	118316.9	1034.[illegible]	38
15.00	9.958E+06	7.838E+05	9.959E+05	1.1151	.0878	110766.4	1193.6	36
16.00	9.564E+06	7.783E+05	1.088E+06	1.2027	.0979	103689.6	1365.[illegible]	35
17.00	9.145E+06	7.726E+05	1.184E+06	1.2873	.1086	96857.9	1551.3	33
18.00	8.703E+06	7.666E+05	1.282E+06	1.3670	.1204	90512.3	1750.5	32
19.00	8.242E+06	7.605E+05	1.382E+06	1.4405	.1329	84565.8	1953.9	31
20.00	7.768E+06	7.543E+05	1.494E+06	1.5062	.1463	790[illegible]	2191.3	29
21.00	7.286E+06	7.480E+05	1.588E+06	1.5630	.1605	73816.4	2435.[illegible]	27
22.00	6.801E+06	7.417E+05	1.692E+06	1.6100	.1756	68978.5	2694.3	25
23.00	6.319E+06	7.354E+05	1.796E+06	1.6466	.1917	64472.[illegible]	297[illegible].2	23
24.00	5.844E+06	7.292E+05	1.901E+06	1.6725	.2087	61276.5	3263.1	21
25.00	5.383E+06	7.232E+05	2.004E+06	1.6876	.2267	56371.5	3574.1	20
26.00	4.939E+06	7.174E+05	2.106E+06	1.6924	.2453	52736.9	3913.[illegible]	18
27.00	4.517E+06	7.120E+05	2.207E+06	1.6872	.266[illegible]	49393.5	4253.3	16
28.00	4.117E+06	7.071E+05	2.305E+06	1.6729	.2873	462[illegible]3.[illegible]	4623.5	15
29.00	3.744E+06	7.028E+05	2.400E+06	1.6503	.3098	43268.2	5015.3	13
30.00	3.398E+06	6.992E+05	2.492E+06	1.6204	.3335	40533.[illegible]	547[illegible]	12
31.00	3.079E+06	6.966E+05	2.581E+06	1.5842	.3585	37982.2	5863.7	11
32.00	2.787E+06	6.951E+05	2.665E+06	1.5428	.3847	35602.[illegible]	6332.8	10
33.00	2.522E+06	6.946E+05	2.746E+06	1.4970	.4124	33379.4	6823.5	9
34.00	2.283E+06	6.962E+05	2.821E+06	1.4479	.4415	31302.5	7342.5	8
35.00	2.069E+06	6.993E+05	2.891E+06	1.3962	.4720	29360.4	7891.4	7
36.00	1.877E+06	7.046E+05	2.955E+06	1.3428	.5040	2754[illegible].9	8471.9	6
37.00	1.707E+06	7.124E+05	3.01[illegible]E+06	1.2883	.5376	2584[illegible].9	9[illegible]96.[illegible]	5
38.00	1.557E+06	7.231E+05	3.06[illegible]E+06	1.2333	.5725	24245.8	9[illegible]35.7	5
39.00	1.425E+06	7.372E+05	3.111E+06	1.1783	.6097	22749.8	10423.2	5
40.00	1.309E+06	7.55[illegible]E+05	3.150E+06	1.1237	.6482	21345.7	11151.[illegible]	4
41.00	1.208E+06	7.773E+05	3.183E+06	1.0698	.6884	20027.[illegible]	11921.7	4
42.00	1.12[illegible]E+06	8.046E+05	3.208E+06	1.0169	.7304	18787.6	12776.1	4
43.00	1.045E+06	8.377E+05	3.226E+06	.9653	.7741	17622.1	13613.4	3
44.00	9.797E+05	8.775E+05	3.237E+06	.9151	.8194	16525.2	14521.9	3
45.00	9.247E+05	9.244E+05	3.241E+06	.8664	.8665	15432.7	15434.[illegible]	3

COMPOSITE PROPERTIES

ER = 4.700E+05
AR = 4.000E-05
UR = .3500

RHO= .0485
FTU= 211250.0
FCU= 45500.0
FSU= 8000.0

FXTU	FYTU	FXCU	FYCU	FXY	AX	AY
211250.0	.0	45500.0	2992.3	1508.6	-1.448E-06	2.931E-05
210439.9	5.1	45470.2	2991.5	1601.6	-1.457E-06	2.930E-05
208044.5	20.4	45380.0	2989.4	1709.1	-1.482E-06	2.930E-05
204164.8	45.9	45227.7	2985.9	1833.0	-1.525E-06	2.929E-05
198957.9	81.7	45010.1	2981.0	1975.1	-1.586E-06	2.927E-05
192621.2	127.9	44723.1	2974.6	2137.5	-1.664E-06	2.925E-05
185375.5	184.5	44361.6	2966.9	2322.2	-1.759E-06	2.922E-05
177448.3	251.8	43919.4	2957.9	2531.5	-1.872E-06	2.919E-05
169058.8	329.7	43390.2	2947.5	2767.4	-2.003E-06	2.915E-05
160467.7	418.6	42767.2	2935.8	3032.2	-2.151E-06	2.910E-05
151669.3	519.6	42043.7	2922.9	3327.9	-2.316E-06	2.904E-05
142987.4	629.9	41213.6	2908.7	3656.5	-2.500E-06	2.898E-05
134480.4	752.7	40272.0	2893.3	4019.7	-2.701E-06	2.890E-05
126235.7	887.4	39215.4	2876.9	4419.1	-2.919E-06	2.881E-05
118316.9	1034.3	38042.7	2859.3	4855.5	-3.155E-06	2.87[illegible]E-05
110766.4	1193.6	36755.2	284[illegible].8	5329.7	-3.4[illegible]8E-06	2.859E-05
103609.6	1365.3	35357.6	2821.4	5841.6	-3.678E-06	2.845E-05
96857.9	1551.3	33837.7	2801.2	6390.6	-3.964E-06	2.829E-05
90512.3	1750.5	32257.0	2780.2	6975.4	-4.265E-06	2.811E-05
84565.8	1963.9	30599.9	2758.7	7593.7	-4.582E-06	2.790E-05
79[illegible].6	2191.9	28874.0	2736.8	8242.7	-4.911E-06	2.767E-05
73816.4	2435.8	27108.8	2714.6	8918.7	-5.252E-06	2.74[illegible]E-05
68978.5	2694.3	25325.3	2692.4	9617.0	-5.602E-06	2.709E-05
64472.0	2971.2	23544.8	2670.3	10332.6	-5.959E-06	2.675E-05
60276.5	3263.1	21788.1	2648.5	11059.6	-6.319E-06	2.635E-05
56371.5	3574.1	20074.6	2627.6	11791.9	-6.679E-06	2.590E-05
52736.9	3907.9	18421.4	2607.5	12522.9	-7.033E-06	2.540E-05
49353.5	4253.3	16843.1	2588.8	13245.9	-7.375E-06	2.483E-05
46203.0	4623.5	15370.9	2571.9	13954.7	-7.700E-06	2.418E-05
43268.2	5015.3	13953.3	2557.3	14642.8	-7.997E-06	2.346E-05
40533.0	5430.0	12655.5	2545.4	15304.7	-8.259E-06	2.266E-05
37982.2	5868.7	11460.0	2536.9	15935.1	-8.474E-06	2.176E-05
35602.0	6332.8	10396.8	2532.4	16529.6	-8.631E-06	2.076E-05
33379.4	6823.5	9374.1	2532.8	17084.7	-8.715E-06	1.967E-05
31302.5	7342.5	8478.3	2539.0	17597.4	-8.712E-06	1.847E-05
29360.4	7891.4	7674.6	2551.9	18065.9	-8.60[illegible]E-06	1.716E-05
27540.9	8471.9	6957.6	2572.7	18486.7	-8.387E-06	1.574E-05
25840.9	9086.0	63[illegible]1.1	2602.8	18855.3	-8.034E-06	1.427E-05
24245.8	9735.7	5738.9	2643.5	19195.5	-7.536E-06	1.262E-05
22749.8	10423.2	5264.5	2696.5	19479.7	-6.882E-06	1.094E-05
21345.7	11151.7	4871.8	2760.8	19718.3	-6.065E-06	9.189E-06
20027.0	11921.7	4454.8	2847.4	19912.1	-5.080E-06	7.403E-06
18787.6	12778.1	4127.9	2949.5	20061.9	-3.931E-06	5.501E-06
17622.1	13613.4	3845.7	3073.2	20168.3	-2.625E-06	3.813E-06
16525.2	14522.9	3613.4	3221.0	20231.9	-1.175E-06	2.068E-06
15492.7	15434.[illegible]	3396.5	3396.8	20253.0	3.932E-07	3.956E-07

KEVLAR 49/EPOXY

FIBER PROPERTIES

VF = .3714
WF = .4290
RHOF= .0524
FTU = 325000.0
FCU = 70000.0
UF = .2200

EF = 1.900E+07
EFT= 1.000E+06
GF = 3.000E+05
AF =-2.000E-06
AFT= 3.300E-05

RESIN PROPERTIES

VR = .6286
WR = .5710
RHOR= .0412
FSU = 8000.0

ER = 4.700E+05
AR = 4.000E-05
UP = .3500

COMPOS[illegible]

RHO= [illegible]
FTU= [illegible]
FCU= [illegible]
FSU= [illegible]

ALPHA	EX	EY	GXY	UXY	UYX	FXTU	FYTU	FXC[illegible]
.00	7.352E+06	7.164E+05	2.140E+05	.3017	.0294	120765.0	-.0	2599
1.00	7.347E+06	7.162E+05	2.161E+05	.3046	.0297	120389.9	4.3	2598
2.00	7.330E+06	7.157E+05	2.223E+05	.3133	.0306	119453.7	17.1	2593
3.00	7.303E+06	7.148E+05	2.327E+05	.3278	.0321	117922.9	38.6	2584
4.00	7.265E+06	7.136E+05	2.471E+05	.3479	.0342	115839.4	68.7	2572
5.00	7.215E+06	7.121E+05	2.656E+05	.3735	.0369	113258.3	107.5	2555
6.00	7.152E+06	7.102E+05	2.880E+05	.4046	.0402	110243.7	155.0	2536
7.00	7.078E+06	7.080E+05	3.142E+05	.4408	.0441	106865.6	211.5	2513
8.00	6.991E+06	7.054E+05	3.441E+05	.4820	.0486	103196.1	276.9	2485
9.00	6.889E+06	7.026E+05	3.775E+05	.5277	.0538	99306.0	351.5	2452
10.00	6.774E+06	6.994E+05	4.143E+05	.5775	.0596	95262.9	435.3	2415
11.00	6.645E+06	6.960E+05	4.542E+05	.6311	.0661	91128.2	528.6	2372
12.00	6.500E+06	6.922E+05	4.972E+05	.6877	.0732	86957.1	631.6	2325
13.00	6.341E+06	6.882E+05	5.430E+05	.7468	.0811	82796.7	744.4	2272
14.00	6.168E+06	6.839E+05	5.913E+05	.8076	.0896	78686.8	867.3	2214
15.00	5.980E+06	6.794E+05	6.420E+05	.8693	.0988	74659.7	1000.5	2153
16.00	5.778E+06	6.747E+05	6.946E+05	.9310	.1087	70740.9	1144.5	2081
17.00	5.563E+06	6.697E+05	7.494E+05	.9918	.1194	66949.6	1299.3	2[illegible]
18.00	5.336E+06	6.646E+05	8.055E+05	1.0507	.1309	63299.9	1465.5	1929
19.00	5.100E+06	6.594E+05	8.630E+05	1.1057	.1431	59800.8	1643.4	1847
20.00	4.855E+06	6.540E+05	9.214E+05	1.1590	.1561	56457.9	1833.3	1761
21.00	4.603E+06	6.486E+05	9.806E+05	1.2067	.1700	53273.5	2035.7	1672
22.00	4.349E+06	6.432E+05	1.040E+06	1.2490	.1848	50247.2	2251.1	1581
23.00	4.091E+06	6.378E+05	1.100E+06	1.2853	.2004	47377.0	2479.9	149[illegible]
24.00	3.834E+06	6.324E+05	1.160E+06	1.3151	.2169	44659.2	2722.7	1397
25.00	3.581E+06	6.272E+05	1.219E+06	1.3381	.2344	42088.9	2980.1	1306
26.00	3.333E+06	6.223E+05	1.277E+06	1.3541	.2528	39660.6	3252.7	1215
27.00	3.092E+06	6.176E+05	1.335E+06	1.3631	.2722	37368.4	3541.2	1127
28.00	2.861E+06	6.134E+05	1.391E+06	1.3653	.2927	35205.7	3846.2	1044
29.00	2.640E+06	6.096E+05	1.445E+06	1.3609	.3142	33166.2	4168.6	963
30.00	2.431E+06	6.065E+05	1.498E+06	1.3503	.3368	31243.7	4509.1	887
31.00	2.235E+06	6.041E+05	1.549E+06	1.3341	.3605	29430.6	4868.7	815
32.00	2.053E+06	6.026E+05	1.597E+06	1.3127	.3854	27721.9	5248.3	748
33.00	1.884E+06	6.022E+05	1.643E+06	1.2868	.4114	26111.1	5649.0	685
34.00	1.728E+06	6.031E+05	1.686E+06	1.2571	.4387	24592.4	6071.7	628
35.00	1.586E+06	6.054E+05	1.726E+06	1.2238	.4671	23160.7	6517.7	575
36.00	1.457E+06	6.095E+05	1.763E+06	1.1879	.4968	21809.6	6988.3	529
37.00	1.341E+06	6.155E+05	1.796E+06	1.1498	.5278	20535.7	7484.8	488
38.00	1.237E+06	6.238E+05	1.826E+06	1.1101	.5600	19332.7	8008.6	449
39.00	1.144E+06	6.347E+05	1.852E+06	1.0691	.5934	18197.4	8561.4	413
40.00	1.061E+06	6.486E+05	1.875E+06	1.0274	.6281	17125.3	9144.7	383
41.00	9.881E+05	6.659E+05	1.893E+06	.9852	.6640	16112.6	9760.3	356
42.00	9.241E+05	6.870E+05	1.907E+06	.9430	.7011	15155.5	10410.3	331
43.00	8.687E+05	7.124E+05	1.918E+06	.9010	.7392	14250.8	11096.6	312
44.00	8.199E+05	7.428E+05	1.924E+06	.8594	.7784	13395.7	11821.5	294
45.00	7.782E+05	7.783E+05	1.926E+06	.8185	.8190	12586.0	12587.3	27[illegible]

ES

COMPOSITE PROPERTIES

EP = 4.700E+05 RHO= .0454
AR = 4.000E-05 FTU= 120765.0
UP = .3500 FCU= 25998.0
FSU= 8000.0

UYX	FXTU	FYTU	FXCU	FYCU	FXY	AX	AY
.0294	120765.0	-.0	25998.0	2512.9	1239.3	-3.122E-07	2.998E-05
.0297	120389.9	4.3	25981.2	2512.3	1308.8	-3.204E-07	2.998E-05
.0306	119453.7	17.1	25930.5	2510.6	1388.4	-3.448E-07	2.997E-05
.0321	117922.9	38.6	25845.2	2507.7	1479.1	-3.856E-07	2.996E-05
.0342	115839.4	68.7	25724.4	2503.6	1582.2	-4.428E-07	2.994E-05
.0369	113258.3	107.5	25556.5	2498.4	1693.6	-5.163E-07	2.992E-05
.0402	110243.7	155.0	25369.8	2492.0	1829.5	-6.062E-07	2.989E-05
.0441	106865.6	211.5	25172.3	2484.5	1975.0	-7.125E-07	2.985E-05
.0486	103196.1	276.9	24851.6	2476.0	2139.0	-8.353E-07	2.981E-05
.0538	99306.0	351.5	24525.5	2466.3	2319.6	-9.745E-07	2.976E-05
.0596	95262.9	435.3	24131.7	2455.7	2518.3	-1.130E-06	2.970E-05
.0661	91128.2	528.6	23728.0	2444.0	2735.9	-1.302E-06	2.963E-05
.0732	86957.1	631.6	23252.7	2431.4	2972.7	-1.490E-06	2.955E-05
.0811	82796.7	744.4	22724.3	2417.8	3228.8	-1.694E-06	2.945E-05
.0896	78686.8	867.3	22142.4	2403.4	3504.2	-1.915E-06	2.934E-05
.0988	74659.7	1000.5	21507.9	2388.1	3799.2	-2.150E-06	2.922E-05
.1087	70740.9	1144.5	20819.5	2372.2	4111.2	-2.400E-06	2.908E-05
.1194	66949.6	1299.3	20082.2	2355.2	4438.8	-2.665E-06	2.891E-05
.1309	63299.9	1465.5	19298.9	2338.4	4782.6	-2.943E-06	2.873E-05
.1431	59800.8	1647.4	18474.3	2320.8	5139.7	-3.233E-06	2.852E-05
.1561	56457.9	1833.3	17614.5	2302.8	5507.7	-3.534E-06	2.828E-05
.1700	53273.5	2035.7	16726.7	2284.7	5884.3	-3.844E-06	2.800E-05
.1848	50247.2	2251.1	15819.0	2266.5	6266.7	-4.160E-06	2.769E-05
.2004	47377.0	2479.9	14900.1	2248.4	6651.9	-4.481E-06	2.734E-05
.2169	44659.2	2722.7	13979.0	2230.7	7037.0	-4.802E-06	2.695E-05
.2344	42088.9	2980.1	13064.7	2213.6	7418.9	-5.120E-06	2.651E-05
.2528	39660.6	3252.7	12156.0	2197.3	7794.8	-5.429E-06	2.600E-05
.2722	37368.4	3541.2	11230.9	2182.1	8161.7	-5.724E-06	2.543E-05
.2927	35205.7	3846.2	10446.6	2168.4	8517.1	-5.998E-06	2.480E-05
.3142	33166.2	4168.5	9639.3	2156.5	8858.6	-6.244E-06	2.409E-05
.3368	31243.7	4509.1	8873.0	2146.8	9184.0	-6.452E-06	2.330E-05
.3605	29430.6	4868.7	8154.2	2139.9	9491.6	-6.613E-06	2.243E-05
.3854	27721.9	5248.3	7482.7	2136.3	9779.9	-6.715E-06	2.147E-05
.4114	26111.1	5649.0	6850.4	2136.5	10047.8	-6.747E-06	2.041E-05
.4387	24592.4	6071.7	6299.0	2141.3	10294.6	-6.695E-06	1.926E-05
.4671	23160.7	6517.7	5756.5	2151.5	10519.6	-6.545E-06	1.801E-05
.4968	21809.6	6998.3	5292.7	2167.8	10722.5	-6.285E-06	1.666E-05
.5278	20535.7	7484.8	4854.4	2191.3	10903.2	-5.904E-06	1.523E-05
.5601	19332.7	8008.6	4480.5	2223.0	11061.9	-5.389E-06	1.371E-05
.5934	18197.4	8561.4	4178.1	2264.2	11198.6	-4.730E-06	1.212E-05
.6281	17125.7	9144.7	3874.7	2316.1	11313.6	-3.923E-06	1.048E-05
.6640	16112.6	9760.3	3566.3	2380.3	11407.2	-2.955E-06	8.808E-06
.7011	15155.5	10410.3	3371.1	2456.4	11479.6	-1.860E-06	7.121E-06
.7392	14253.8	11096.6	3126.0	2552.2	11531.2	-5.140E-07	5.475E-06
.7784	13395.7	11821.5	2948.0	2663.6	11562.0	7.590E-07	3.811E-06
.8190	12585.0	12587.0	2794.7	2794.9	11572.3	2.242E-06	2.239E-06

KEVLAR 49/EPOXY

FIBER PROPERTIES		RESIN PROPERTIES		COMPO
VF = .4333	EF = 1.900E+07	VR = .5667	ER = 4.700E+05	RHO=
WF = .4930	EFT= 1.000E+06	WR = .5070	AR = 4.000E-05	FTU=
RHOF= .0524	GF = 3.000E+05	RHOR= .0412	UR = .3500	FCU=
FTU = 325000.0	AF =-2.000E-06	FSU = 8000.0		FSU=
FCU = 73000.0	AFT= 3.300E-05			
UF = .2200				

ALPHA	EX	EY	GXY	UXY	UYX	FXTU	FYTU	F
.00	8.499E+06	7.392E+05	2.210E+05	.2937	.0255	140822.5	.0	303
1.00	8.493E+06	7.390E+05	2.234E+05	.2970	.0258	140411.2	4.5	303
2.00	8.474E+06	7.385E+05	2.307E+05	.3068	.0267	139190.6	17.9	302
3.00	8.442E+06	7.376E+05	2.428E+05	.3271	.0282	137199.6	40.2	301
4.00	8.399E+06	7.363E+05	2.597E+05	.3459	.0303	134499.5	71.6	300
5.00	8.339E+06	7.347E+05	2.812E+05	.3749	.0330	131169.7	112.0	298
6.00	8.266E+06	7.328E+05	3.073E+05	.4100	.0363	127302.0	161.6	295
7.00	8.179E+06	7.306E+05	3.379E+05	.4510	.0403	122994.9	220.5	293
8.00	8.076E+06	7.279E+05	3.727E+05	.4975	.0448	118348.3	288.7	28
9.00	7.956E+06	7.251E+05	4.117E+05	.5492	.0500	113458.4	366.5	28
10.00	7.820E+06	7.217E+05	4.546E+05	.6055	.0559	108415.0	453.9	281
11.00	7.666E+06	7.181E+05	5.012E+05	.6659	.0624	103297.9	551.3	27
12.00	7.494E+06	7.143E+05	5.513E+05	.7297	.0695	98176.6	658.7	27
13.00	7.304E+06	7.101E+05	6.047E+05	.7951	.0774	93109.1	776.4	26
14.00	7.096E+06	7.057E+05	6.611E+05	.8642	.0859	88142.3	904.7	257
15.00	6.871E+06	7.010E+05	7.202E+05	.9331	.0952	83313.1	1043.8	24
16.00	6.628E+06	6.961E+05	7.817E+05	1.0017	.1052	78648.8	1194.1	24
17.00	6.369E+06	6.910E+05	8.454E+05	1.0688	.1160	74169.1	1355.9	23
18.00	6.097E+06	6.857E+05	9.108E+05	1.1335	.1275	69886.4	1529.6	22
19.00	5.812E+06	6.803E+05	9.778E+05	1.1945	.1398	65808.0	1715.5	21
20.00	5.518E+06	6.748E+05	1.046E+06	1.2508	.1530	61936.4	1914.0	20
21.00	5.217E+06	6.692E+05	1.115E+06	1.3015	.1669	58270.5	2125.3	19
22.00	4.912E+06	6.635E+05	1.185E+06	1.3458	.1816	54806.8	2351.1	18
23.00	4.605E+06	6.579E+05	1.254E+06	1.3829	.1976	51539.5	2590.6	16
24.00	4.301E+06	6.524E+05	1.324E+06	1.4124	.2147	48461.5	2844.9	15
25.00	4.001E+06	6.471E+05	1.393E+06	1.4341	.2319	45564.8	3114.6	14
26.00	3.709E+06	6.419E+05	1.461E+06	1.4478	.2506	42840.7	3400.3	13
27.00	3.427E+06	6.371E+05	1.528E+06	1.4537	.2707	40280.1	3702.8	12
28.00	3.157E+06	6.327E+05	1.593E+06	1.4521	.291	37874.2	4022.8	11
29.00	2.901E+06	6.289E+05	1.657E+06	1.4433	.3128	35613.9	4361.2	10
30.00	2.661E+06	6.256E+05	1.719E+06	1.4279	.335	33490.5	4718.9	9
31.00	2.436E+06	6.232E+05	1.778E+06	1.4065	.3599	31495.5	5096.9	8
32.00	2.227E+06	6.218E+05	1.834E+06	1.3799	.3852	29621.2	5496.2	8
33.00	2.035E+06	6.214E+05	1.887E+06	1.3487	.4119	27859.4	5917.8	7
34.00	1.860E+06	6.224E+05	1.937E+06	1.3136	.4396	26203.1	6363.1	6
35.00	1.700E+06	6.250E+05	1.984E+06	1.2754	.4683	24645.4	6833.2	6
36.00	1.556E+06	6.293E+05	2.027E+06	1.2345	.4992	23179.6	7329.6	5
37.00	1.427E+06	6.358E+05	2.066E+06	1.1918	.5317	21801.5	7853.8	5
38.00	1.311E+06	6.447E+05	2.101E+06	1.1476	.5641	20501.6	8407.4	4
39.00	1.209E+06	6.564E+05	2.131E+06	1.1026	.5987	19278.0	8992.0	4
40.00	1.118E+06	6.712E+05	2.157E+06	1.0571	.6346	18124.8	9609.6	4
41.00	1.038E+06	6.897E+05	2.179E+06	1.0115	.6718	17037.5	10262.2	3
42.00	9.686E+05	7.123E+05	2.196E+06	.9661	.7104	16011.8	10951.9	3
43.00	9.079E+05	7.396E+05	2.208E+06	.9211	.7504	15043.8	11681.1	3
44.00	8.555E+05	7.721E+05	2.215E+06	.8769	.7914	14129.9	12452.2	3
45.00	8.105E+05	8.105E+05	2.218E+06	.8336	.8337	13266.6	13266.0	2

S

COMPOSITE PROPERTIES

EP = 4.700E+05 RHO= .0461
AR = 4.000E-05 FTU= 140822.5
UP = .3500 FCU= 30331.0
FSU= 8000.0

THIS PAGE IS BEST QUALITY PRACTICABLE FROM COPY FURNISHED TO DDQ

X	FXTU	FYTU	FXCU	FYCU	FXY	AX	AY
255	140822.5	.0	30331.0	2619.9	1301.4	-6.838E-07	2.979E-05
258	140411.2	4.5	30311.2	2619.3	1376.7	-6.921E-07	2.978E-05
267	139190.6	17.9	30251.7	2617.5	1463.1	-7.170E-07	2.978E-05
282	137199.6	40.2	30151.4	2614.4	1562.0	-7.587E-07	2.976E-05
303	134499.5	71.6	300[illegible]9.0	2610.1	1674.7	-8.170E-07	2.975E-05
33[illegible]	131169.7	112.0	29822.6	2604.7	1802.4	-8.920E-07	2.972E-05
363	127302.0	161.6	29589.6	2598.0	1946.6	-9.837E-07	2.970E-05
403	122994.9	220.5	29307.3	2590.2	2108.5	-1.092E-06	2.966E-05
448	118348.3	288.7	28972.7	2581.2	2289.5	-1.218E-06	2.962E-05
500	113458.4	366.5	28582.6	2571.1	2490.6	-1.360E-06	2.957E-05
559	108415.0	453.9	28173.8	2559.9	2713.1	-1.519E-06	2.951E-05
624	103297.9	551.3	27623.4	2547.6	2957.7	-1.695E-06	2.944E-05
695	98176.6	658.7	27049.0	2534.4	3225.2	-1.887E-06	2.936E-05
774	93109.1	776.4	26418.9	2520.1	3515.9	-2.095E-06	2.927E-05
859	88142.3	904.7	25702.2	2505.0	3829.9	-2.322E-06	2.916E-05
952	83313.1	1043.8	24929.3	2489.0	4166.9	-2.563E-06	2.904E-05
052	78648.8	1194.1	24092.1	2472.3	4526.3	-2.820E-05	2.890E-05
16[illegible]	74169.1	1355.9	23193.7	2454.8	4906.8	-3.092E-06	2.873E-05
275	69886.4	1529.6	22239.3	2436.8	5307.0	-3.378E-06	2.855E-05
398	65808.0	1715.5	21235.5	2418.3	5724.6	-3.677E-06	2.834E-05
53[illegible]	61936.4	1914.0	20190.4	2399.4	6157.3	-3.967E-06	2.810E-05
669	58270.5	2125.9	19113.9	2380.3	6602.2	-4.308E-06	2.783E-05
818	54806.8	2351.1	18016.1	2361.2	7056.0	-4.635E-06	2.752E-05
976	51539.5	2590.6	16908.7	2342.2	7515.3	-4.968E-06	2.717E-05
147	48461.5	2844.9	15803.1	2323.5	7976.4	-5.302E-06	2.677E-05
319	45564.8	3114.6	14710.7	2305.5	8435.6	-5.633E-06	2.633E-05
506	42840.7	3400.3	13642.2	2288.4	8889.1	-5.957E-06	2.582E-05
707	40280.1	3702.8	12607.2	2272.4	9333.3	-6.268E-06	2.525E-05
91[illegible]	37874.2	4022.8	11614.2	2257.9	9764.3	-6.558E-06	2.462E-05
128	35613.9	4361.2	10670.1	2245.4	10183.4	-6.821E-06	2.39[illegible]E-05
358	33490.5	4718.9	9790.2	2235.2	10577.3	-7.047E-06	2.311E-05
599	31495.5	5096.9	8948.3	2227.9	10953.1	-7.225E-06	2.223E-05
857	29621.2	5496.2	8176.5	2224.1	11305.9	-7.345E-06	2.125E-05
1[illegible]9	27859.4	5917.8	7455.9	2224.4	11634.1	-7.393E-06	2.018E-05
396	26213.1	6363.1	6816.0	2229.6	11936.4	-7.356E-06	1.901E-05
683	24645.4	6833.2	6225.4	2241.4	12212.2	-7.221E-06	1.774E-05
992	23179.6	7329.6	5692.1	2257.8	12461.9	-6.973E-06	1.638E-05
31[illegible]	21890.5	7853.8	5213.2	2282.9	12682.4	-6.630E-06	1.491E-05
641	20501.6	8407.4	4795.6	2316.8	12875.7	-6.089E-06	1.337E-05
987	19278.0	8992.0	44[illegible]5.8	2360.9	13044.1	-5.431E-06	1.175E-05
346	18124.8	9609.5	4[illegible]70.3	2416.6	13184.8	-4.620E-06	1.007E-05
718	17037.5	10262.2	3775.4	2495.6	13299.3	-3.652E-06	8.[illegible]58E-06
7104	16011.8	10951.9	3517.6	2569.6	13387.8	-2.532E-06	6.633E-06
750[illegible]	15043.8	11681.1	3293.4	267[illegible].7	13450.8	-1.265E-06	4.421E-06
7914	14129.9	12452.2	3099.6	2791.1	13488.5	1.331E-07	3.249E-06
8337	13266.6	13266.0	2933.1	2933.3	13501.0	1.645E-06	1.644E-06

S GLASS/EPOXY

FIBER PROPERTIES

VF = .5000	EF = 1.260E+07	
WF = .6860	EFT= 1.260E+07	
RHOF= .0900	GF = 4.000E+05	
FTU = 325000.0	AF = 2.200E-06	
FCU = 215000.0	AFT= 2.200E-06	
UF = .2200		

RESIN PROPERTIES

VR = .5000	ER = 4.700E+05
WR = .3140	AR = 4.000E-05
RHOR= .0412	UR = .3500
FSU = 8000.0	

COMP[illegible]

RHO[illegible]
FTU[illegible]
FCU[illegible]
FSU[illegible]

ALPHA	EX	EY	GXY	UXY	UYX	FXTU	FYTU
.00	6.535E+06	1.823E+06	2.631E+05	.2850	.0795	162500.0	.0
1.00	6.530E+06	1.822E+06	2.651E+05	.2861	.0798	162193.1	8.0
2.00	6.517E+06	1.819E+06	2.709E+05	.2895	.0808	161278.8	31.9
3.00	6.494E+06	1.815E+06	2.807E+05	.2951	.0825	159775.1	71.8
4.00	6.461E+06	1.809E+06	2.943E+05	.3030	.0848	157711.4	127.9
5.00	6.420E+06	1.802E+06	3.116E+05	.3130	.0879	155125.9	200.1
6.00	6.369E+06	1.793E+06	3.327E+05	.3252	.0916	152068.7	288.6
7.00	6.308E+06	1.782E+06	3.573E+05	.3396	.0959	148589.8	393.6
8.00	6.238E+06	1.77[illegible]E+06	3.854E+05	.3561	.1010	144747.0	515.3
9.00	6.158E+06	1.756E+06	4.168E+05	.3745	.1068	140598.9	653.3
10.00	6.069E+06	1.741E+06	4.513E+05	.3950	.1133	136204.2	809.6
11.00	5.969E+06	1.723E+06	4.889E+05	.4173	.1205	131619.5	982.3
12.00	5.861E+06	1.703E+06	5.293E+05	.4414	.1284	126898.7	1173.3
13.00	5.741E+06	1.684E+06	5.723E+05	.4671	.1371	122091.4	1383.0
14.00	5.612E+06	1.660E+06	6.177E+05	.4944	.1465	117242.7	1610.7
15.00	5.473E+06	1.637E+06	6.654E+05	.5229	.1566	112392.5	1857.4
16.00	5.325E+06	1.615E+06	7.149E+05	.5526	.1676	107575.4	2123.7
17.00	5.168E+06	1.588E+06	7.662E+05	.5832	.1793	102821.0	2409.9
18.00	5.002E+06	1.561E+06	8.190E+05	.6145	.1916	98153.9	2716.7
19.00	4.828E+06	1.532E+06	8.731E+05	.6463	.2051	93594.3	3044.6
20.00	4.646E+06	1.502E+06	9.279E+05	.6781	.2192	89157.6	3394.4
21.00	4.458E+06	1.471E+06	9.835E+05	.7098	.2341	84856.7	3766.8
22.00	4.264E+06	1.438E+06	1.04[illegible]E+06	.7410	.2499	80699.7	4162.5
23.00	4.06[illegible]E+06	1.405E+06	1.096E+06	.7713	.2665	76692.9	4582.3
24.00	3.863E+06	1.371E+06	1.152E+06	.8005	.2840	72839.8	5027.2
25.00	3.659E+06	1.336E+06	1.207E+06	.8282	.3023	69141.9	5498.0
26.00	3.454E+06	1.30[illegible]E+06	1.262E+06	.8546	.3215	65599.1	5995.8
27.00	3.249E+06	1.264E+06	1.316E+06	.8776	.3415	62209.9	6521.6
28.00	3.046E+06	1.228E+06	1.369E+06	.8988	.3624	58971.7	7076.5
29.00	2.847E+06	1.192E+06	1.42[illegible]E+06	.9173	.3841	55880.9	7661.9
30.00	2.652E+06	1.157E+06	1.47[illegible]E+06	.9328	.4067	52933.5	8279.0
31.00	2.465E+06	1.122E+06	1.517E+06	.9451	.4300	50124.9	8929.2
32.00	2.285E+06	1.[illegible]87E+06	1.563E+06	.9543	.4541	4745[illegible].2	9614.[illegible]
33.00	2.114E+06	1.055E+06	1.60[illegible]E+06	.9600	.4790	44904.2	10335.0
34.00	1.957E+06	1.023E+06	1.645E+06	.9625	.5045	42481.7	11093.7
35.00	1.812E+06	9.945E+05	1.684E+06	.9615	.5306	40177.4	11892.2
36.00	1.667E+06	9.661E+05	1.718E+06	.9573	.5573	37985.0	12732.1
37.00	1.536E+06	9.449E+05	1.751E+06	.9500	.5844	35902.4	13615.7
38.00	1.421E+06	9.25[illegible]E+05	1.778E+06	.9397	.6119	33921.5	14544.9
39.00	1.319E+06	9.103E+05	1.803E+06	.9266	.6397	32038.3	15522.2
40.00	1.228E+06	9.011E+05	1.824E+06	.9109	.6676	30248.2	16549.9
41.00	1.15[illegible]E+06	8.956E+05	1.841E+06	.8929	.6954	28546.4	176[illegible].5
42.00	1.087E+06	[illegible]	1.855E+06	.8726	.7230	26928.7	18767.1
43.00	1.028E+06	9.[illegible]E+05	1.864E+06	.8509	.7502	2539[illegible].8	19962.2
44.00	9.837E+05	9.23[illegible]E+05	1.87[illegible]E+06	.8274	.7769	23928.7	21219.[illegible]
45.00	9.486E+05	9.4[illegible]E+05	1.872E+06	.8027	.8027	22538.7	225[illegible].9

COMPOSITE PROPERTIES

ER = 4.700E+05
AR = 4.100E-05
UR = .3500

RHO= .0656
FTU= 162500.0
FCU= 107500.0
FSU= 8000.0

FXTU	FYTU	FXCU	FYCU	FXY	AX	AY
162500.0	.0	107500.0	29489.2	5436.0	3.559E-06	1.175E-05
162193.1	8.0	107434.4	29476.7	5695.0	3.557E-06	1.175E-05
161278.8	31.9	107237.2	29439.0	5995.5	3.551E-06	1.175E-05
159775.1	71.8	106907.7	29376.2	6341.0	3.540E-06	1.176E-05
157711.4	127.9	106444.5	29298.3	6734.6	3.526E-06	1.176E-05
155126.9	200.1	105845.8	29175.4	7177.9	3.507E-06	1.177E-05
152068.7	288.6	105109.3	29037.5	7671.9	3.483E-06	1.178E-05
148589.8	393.6	104232.4	28874.6	8215.8	3.456E-06	1.179E-05
144747.0	515.3	103212.0	28686.8	8811.7	3.424E-06	1.180E-05
140598.9	653.3	102045.2	28474.2	9455.3	3.387E-06	1.182E-05
136204.2	809.6	100729.7	28237.0	10145.7	3.346E-06	1.183E-05
131619.5	982.3	99259.3	27975.3	10880.6	3.300E-06	1.185E-05
126898.7	1173.3	97634.4	27689.4	11657.3	3.250E-06	1.186E-05
122091.4	1383.0	95851.5	27379.4	12473.0	3.195E-06	1.188E-05
117242.7	1610.7	93909.0	27045.7	13324.9	3.134E-06	1.190E-05
112392.5	1857.4	91806.0	26688.7	14209.8	3.069E-06	1.192E-05
107575.4	2123.7	89543.1	26308.9	15124.7	2.999E-06	1.194E-05
102821.0	2409.9	87122.1	25906.7	16065.5	2.925E-06	1.195E-05
98153.9	2716.7	84546.6	25483.0	17032.0	2.845E-06	1.197E-05
93594.3	3044.6	81822.4	25038.6	18017.9	2.760E-06	1.199E-05
89157.0	3394.4	78957.3	24574.3	19020.8	2.670E-06	1.200E-05
84856.7	3766.8	75961.5	24091.3	20037.2	2.576E-06	1.201E-05
80699.7	4162.5	72848.2	23591.1	21063.4	2.478E-06	1.202E-05
76692.9	4582.3	69632.8	23075.0	22095.6	2.375E-06	1.202E-05
72839.8	5027.2	66333.5	22545.1	23129.7	2.271E-06	1.202E-05
69141.9	5498.0	62971.1	22003.3	24161.6	2.163E-06	1.201E-05
65599.1	5995.8	59568.4	21452.2	25186.7	2.054E-06	1.198E-05
62209.9	6521.6	56150.2	20894.5	26200.5	1.945E-06	1.195E-05
58971.7	7076.5	52742.6	20333.5	27198.1	1.840E-06	1.190E-05
55880.9	7661.9	49372.6	19772.9	28174.7	1.738E-06	1.183E-05
52933.5	8279.0	46067.1	19216.5	29125.1	1.645E-06	1.174E-05
50124.9	8929.2	42852.5	18670.1	30044.3	1.563E-06	1.163E-05
47450.2	9614.1	39753.9	18138.0	30927.1	1.497E-06	1.148E-05
44914.2	10335.0	36794.5	17626.5	31768.6	1.453E-06	1.129E-05
42481.7	11093.7	33994.8	17142.4	32563.8	1.438E-06	1.107E-05
40177.4	11892.2	31372.3	16693.0	33307.8	1.459E-06	1.079E-05
37986.0	12732.1	28941.3	16286.5	33996.1	1.525E-06	1.046E-05
35902.4	13615.7	26712.2	15932.1	34624.4	1.643E-06	1.008E-05
33921.5	14544.9	24691.9	15639.3	35188.7	1.824E-06	9.628E-06
32038.3	15522.2	22883.7	15418.9	35685.4	2.075E-06	9.118E-06
30248.2	16549.9	21287.5	15282.1	36111.2	2.402E-06	8.548E-06
28546.4	17636.5	19900.1	15240.9	36463.5	2.809E-06	7.923E-06
26928.7	18767.1	18715.7	15308.1	36739.9	3.295E-06	7.255E-06
25390.8	19952.2	17726.0	15496.5	36938.7	3.855E-06	6.557E-06
23928.7	21219.1	16921.1	15819.5	37058.4	4.473E-06	5.846E-06
22538.7	22541.9	16299.5	16290.4	37098.3	5.149E-06	5.148E-06

KEVLAR 49/EPOXY

FIBER PROPERTIES

VF = .5000
WF = .5598
RHOF= .0524
FTU = 325000.0
FCU = 70000.0
UF = .2200

EF = 1.900E+07
EFT= 1.000E+06
GF = 3.000E+05
AF =-2.000E-06
AFT= 3.300E-05

RESIN PROPERTIES

VR = .5000
WR = .4402
RHOR= .0412
FSU = 8000.0

ER = 4.70[illegible]05
AR = 4.00[illegible]05
UR = .350[illegible]

COMP[illegible]

RHO=
FTU=
FCU=
FSU=

ALPHA	EX	EY	GXY	UXY	UYX	FXTU	FYTU
0.00	9.735E+06	7.648E+05	2.288E+05	.2850	.0224	162500.0	.0
1.00	9.728E+06	7.646E+05	2.316E+05	.2887	.0227	161975.1	4.7
2.00	9.706E+06	7.641E+05	2.400E+05	.2996	.0236	160419.4	18.6
3.00	9.670E+06	7.631E+05	2.540E+05	.3179	.0251	157887.9	42.0
4.00	9.618E+06	7.618E+05	2.734E+05	.3433	.0272	154466.9	74.7
5.00	9.551E+06	7.602E+05	2.983E+05	.3757	.0299	150267.2	116.9
6.00	9.467E+06	7.582E+05	3.284E+05	.4149	.0332	145415.2	168.6
7.00	9.366E+06	7.558E+05	3.636E+05	.4606	.0372	140344.9	230.0
8.00	9.246E+06	7.531E+05	4.038E+05	.5124	.0417	134289.7	301.2
9.00	9.106E+06	7.501E+05	4.488E+05	.5700	.0470	128276.0	382.4
10.00	8.947E+06	7.467E+05	4.983E+05	.6328	.0529	122118.7	473.7
11.00	8.766E+06	7.430E+05	5.521E+05	.7000	.0593	115918.1	575.3
12.00	8.563E+06	7.390E+05	6.099E+05	.7708	.0665	109758.8	687.4
13.00	8.339E+06	7.347E+05	6.715E+05	.8445	.0744	103769.4	810.3
14.00	8.093E+06	7.301E+05	7.365E+05	.9196	.0830	97823.4	944.3
15.00	7.825E+06	7.252E+05	8.047E+05	.9957	.0923	92140.9	1089.6
16.00	7.537E+06	7.202E+05	8.756E+05	1.0709	.1023	86690.1	1246.7
17.00	7.230E+06	7.149E+05	9.491E+05	1.1442	.1131	81489.3	1415.7
18.00	6.907E+06	7.094E+05	1.025E+06	1.2143	.1247	76548.6	1597.2
19.00	6.569E+06	7.038E+05	1.102E+06	1.2798	.1371	71871.5	1791.6
20.00	6.221E+06	6.981E+05	1.181E+06	1.3397	.1503	67455.7	1999.2
21.00	5.865E+06	6.922E+05	1.260E+06	1.3929	.1644	63296.9	2220.7
22.00	5.505E+06	6.864E+05	1.347E+06	1.4385	.1794	59390.2	2456.5
23.00	5.145E+06	6.806E+05	1.421E+06	1.4759	.1953	55720.7	2707.2
24.00	4.788E+06	6.749E+05	1.501E+06	1.5046	.2121	52279.3	2973.4
25.00	4.438E+06	6.693E+05	1.580E+06	1.5245	.2299	49054.2	3255.9
26.00	4.099E+06	6.640E+05	1.659E+06	1.5355	.2487	46033.2	3555.2
27.00	3.773E+06	6.590E+05	1.736E+06	1.5379	.2686	43204.1	3872.3
28.00	3.463E+06	6.545E+05	1.812E+06	1.5321	.2896	40555.1	4207.3
29.00	3.170E+06	6.505E+05	1.885E+06	1.5188	.3117	38074.6	4562.9
30.00	2.896E+06	6.472E+05	1.956E+06	1.4985	.3349	35751.5	4938.4
31.00	2.641E+06	6.447E+05	2.024E+06	1.4721	.3594	33575.2	5335.3
32.00	2.406E+06	6.432E+05	2.090E+06	1.4403	.3851	31535.8	5754.8
33.00	2.190E+06	6.429E+05	2.151E+06	1.4040	.4121	29623.8	6198.1
34.00	1.995E+06	6.440E+05	2.209E+06	1.3539	.4404	27830.5	6666.4
35.00	1.817E+06	6.468E+05	2.263E+06	1.3208	.4701	26147.8	7161.3
36.00	1.658E+06	6.515E+05	2.312E+06	1.2754	.5011	24568.0	7684.2
37.00	1.516E+06	6.584E+05	2.357E+06	1.2284	.5336	23063.9	8236.7
38.00	1.389E+06	6.678E+05	2.397E+06	1.1803	.5676	21689.1	8620.5
39.00	1.276E+06	6.803E+05	2.433E+06	1.1315	.6030	20377.4	9437.7
40.00	1.178E+06	6.961E+05	2.463E+06	1.0826	.6399	19143.2	10090.3
41.00	1.091E+06	7.150E+05	2.488E+06	1.0339	.6784	17981.3	10780.3
42.00	1.015E+06	7.399E+05	2.507E+06	.9857	.7183	16886.8	11510.3
43.00	9.499E+05	7.691E+05	2.521E+06	.9362	.7595	15855.3	12282.8
44.00	8.934E+05	8.039E+05	2.529E+06	.8918	.8024	14862.7	13100.5
45.00	8.450E+05	8.451E+05	2.532E+06	.8464	.8465	13965.2	13966.6

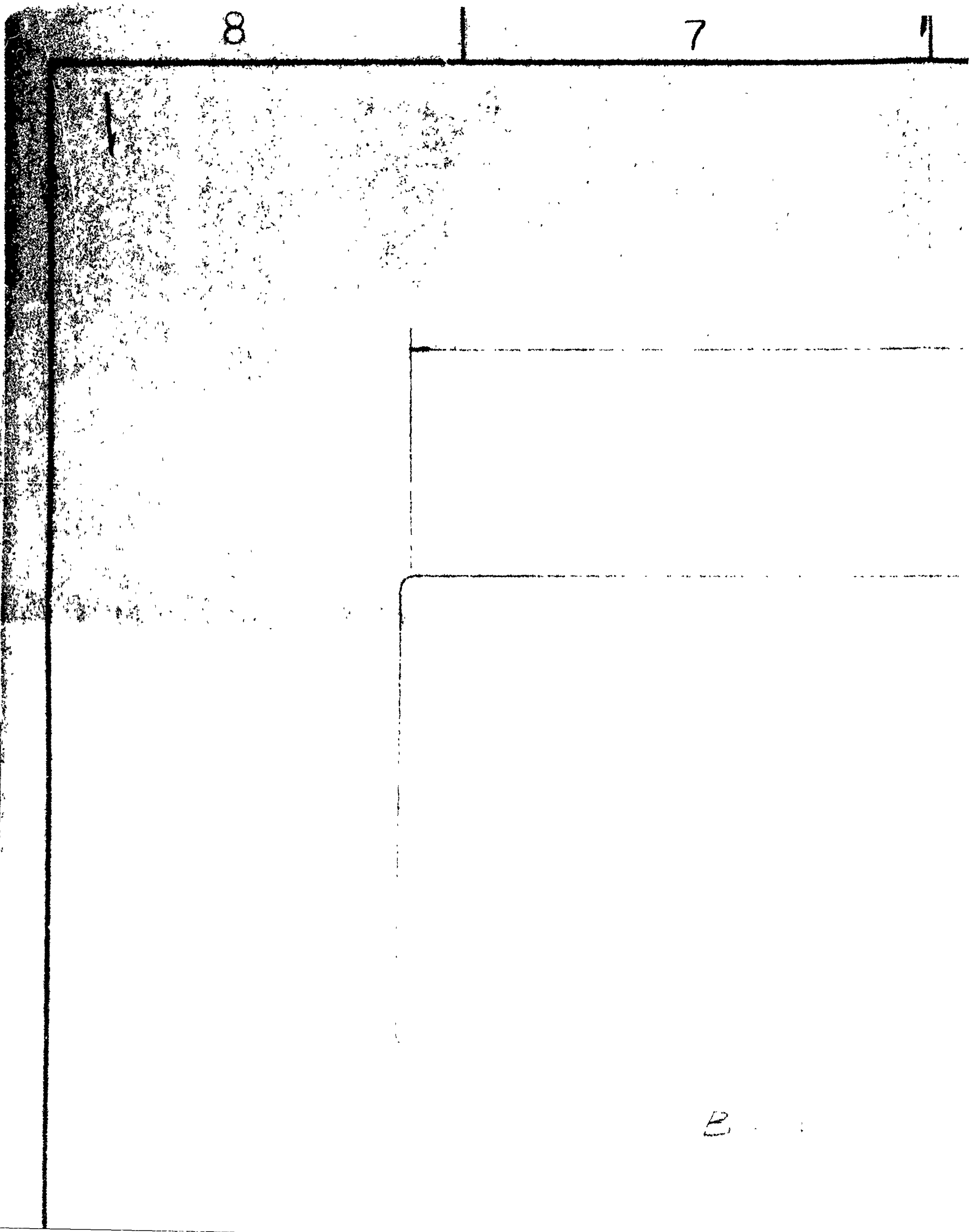
COMPOSITE PROPERTIES

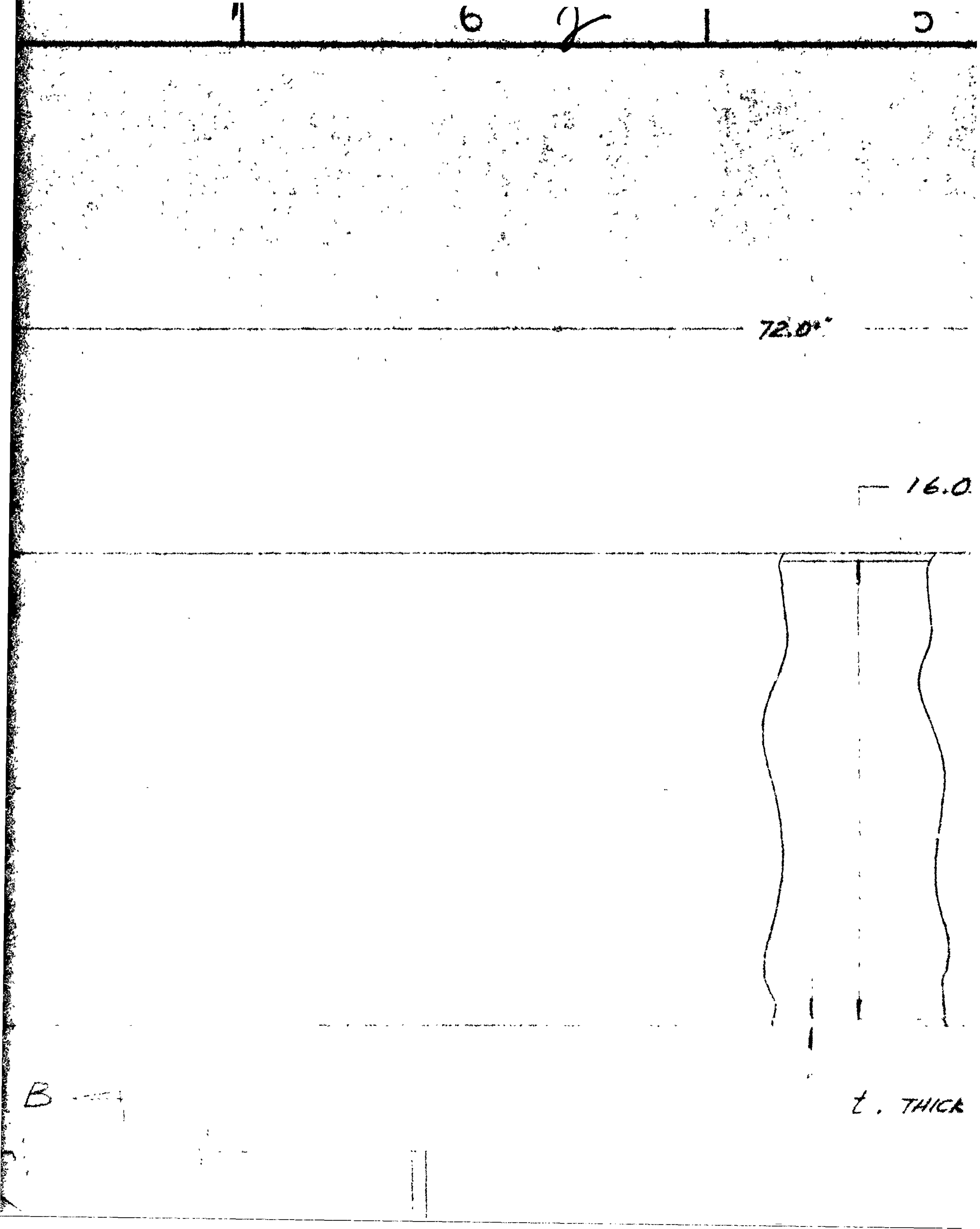
ER = 4.700E+05 RHO= .0468
AR = 4.000E-05 FTU= 162500.0
UR = .350 FCU= 35000.0
FSU= 8000.0

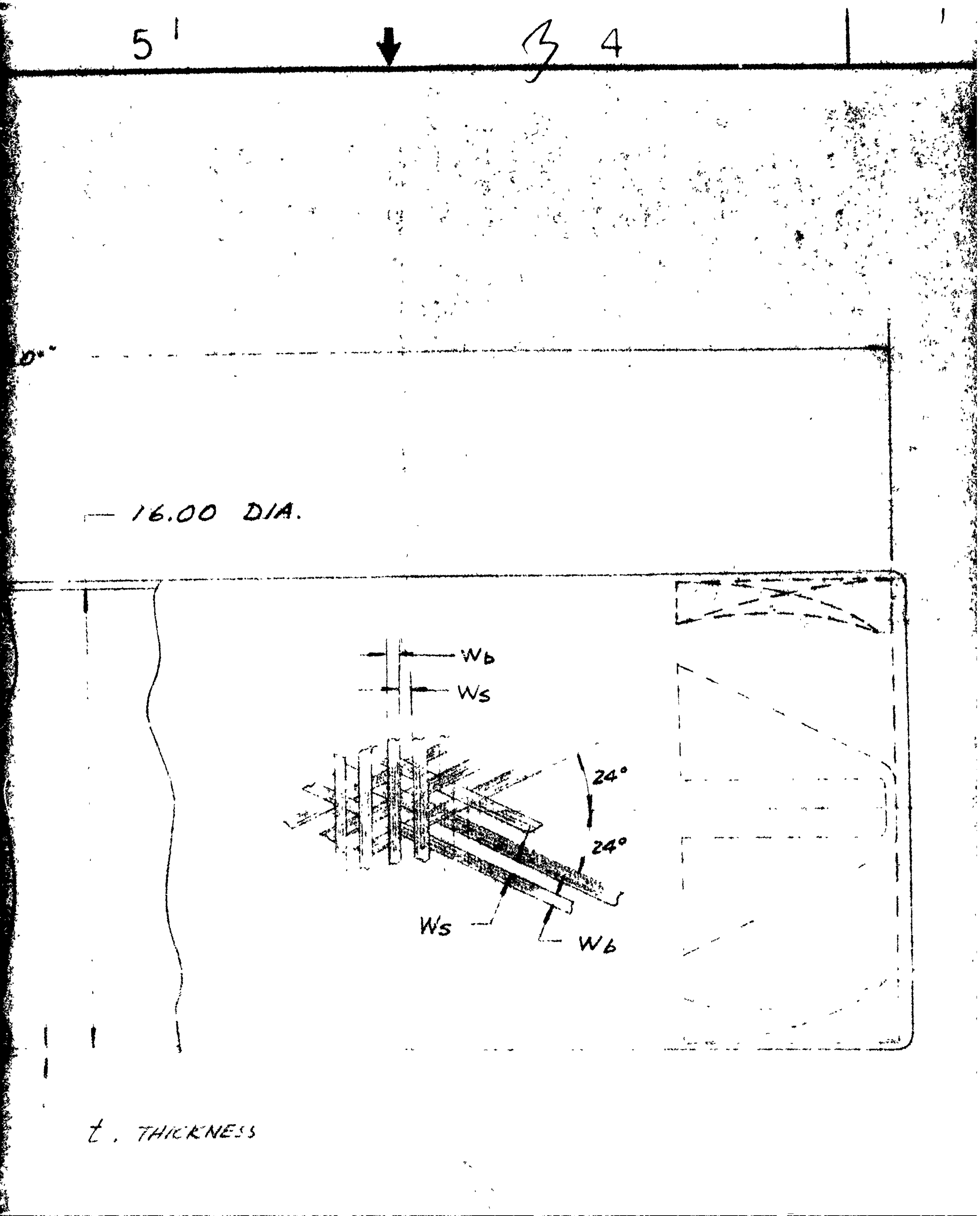
FXTU	FYTU	FYCU	FYCU	FXY	AX	AY
162500.0	.0	35000.0	2733.5	1765.9	-9.861E-07	2.961E-05
161975.1	4.7	34977.1	2732.8	1446.9	-9.946E-07	2.961E-05
160419.4	18.6	34908.1	2731.0	1540.2	-1.020E-06	2.960E-05
157887.9	42.0	34791.7	2727.7	1647.2	-1.062E-06	2.958E-05
154466.9	74.7	34626.1	2723.2	1769.4	-1.121E-06	2.957E-05
150267.2	116.9	34408.7	2717.5	1908.5	-1.198E-06	2.954E-05
145415.2	168.6	34176.4	2710.5	2065.9	-1.291E-06	2.952E-05
140044.9	230.0	33805.3	2702.3	2243.7	-1.401E-06	2.948E-05
134289.7	301.2	33411.6	2692.9	2442.1	-1.528E-06	2.944E-05
128276.0	382.4	32951.0	2682.3	2663.9	-1.673E-06	2.939E-05
122118.7	473.7	32419.4	2670.5	2910.2	-1.835E-06	2.933E-05
115918.1	575.3	31913.0	2657.7	3182.1	-2.014E-06	2.926E-05
109758.8	687.4	31128.6	2643.8	3480.6	-2.210E-06	2.919E-05
103769.4	810.3	30353.9	2628.9	3806.4	-2.423E-06	2.909E-05
97823.4	944.3	29518.0	2613.0	4159.9	-2.652E-06	2.899E-05
92140.9	1089.6	28591.5	2596.2	4541.1	-2.895E-06	2.887E-05
86690.1	1246.7	27586.9	2578.6	4949.3	-3.161E-06	2.873E-05
81489.3	1415.7	26508.7	2560.3	5383.6	-3.439E-06	2.857E-05
76548.6	1597.2	25363.7	2541.4	5842.4	-3.731E-06	2.838E-05
71871.5	1791.6	24160.7	2521.9	6323.6	-4.036E-06	2.818E-05
67456.7	1999.2	22910.4	2502.1	6824.4	-4.354E-06	2.794E-05
63298.9	2220.7	21625.3	2482.1	7341.7	-4.683E-06	2.767E-05
59390.2	2456.5	20319.1	2462.0	7871.8	-5.019E-06	2.736E-05
55720.7	2707.2	19005.9	2442.0	8410.7	-5.361E-06	2.701E-05
52279.3	2973.4	17700.3	2422.4	8953.9	-5.706E-06	2.661E-05
49054.2	3255.9	16415.8	2403.5	9496.9	-6.049E-06	2.617E-05
46033.2	3555.2	15155.5	2385.4	10035.3	-6.384E-06	2.566E-05
43204.1	3872.3	13950.6	2368.6	10564.3	-6.703E-06	2.509E-05
40555.1	4207.3	12810.6	2353.3	11079.7	-7.012E-06	2.445E-05
38074.6	4562.9	11723.0	2340.1	11577.5	-7.293E-06	2.373E-05
35751.5	4938.4	10703.4	2329.4	12054.0	-7.523E-06	2.294E-05
33575.2	5335.3	9755.4	2321.8	12506.0	-7.721E-06	2.205E-05
31535.8	5754.8	8880.6	2317.3	12931.1	-7.855E-06	2.107E-05
29623.8	6198.1	8079.1	2318.1	13326.7	-7.917E-06	1.998E-05
27830.5	6666.4	7349.7	2323.6	13691.5	-7.894E-06	1.880E-05
26147.8	7161.3	6690.2	2335.1	14024.4	-7.770E-06	1.752E-05
24568.0	7684.2	6097.2	2353.7	14324.7	-7.533E-06	1.613E-05
23083.9	8236.7	5567.1	2380.3	14592.2	-7.167E-06	1.465E-05
21689.1	8820.5	5095.6	2416.5	14826.7	-6.651E-06	1.307E-05
20377.4	9437.7	4678.5	2463.4	15028.6	-5.905E-06	1.143E-05
19143.2	10090.3	4311.3	2522.8	15198.3	-5.193E-06	9.724E-06
17981.3	10780.3	3989.7	2596.5	15336.5	-4.216E-06	7.982E-06
16886.8	11510.3	3709.3	2686.4	15443.0	-3.084E-06	6.227E-06
15855.3	12282.8	3466.2	2794.9	15518.5	-1.401E-06	4.485E-06
14882.7	13100.5	3256.7	2924.2	15564.2	-3.624E-07	2.784E-06
13965.2	13966.6	3077.3	3077.3	15579.3	1.155E-06	1.152E-06

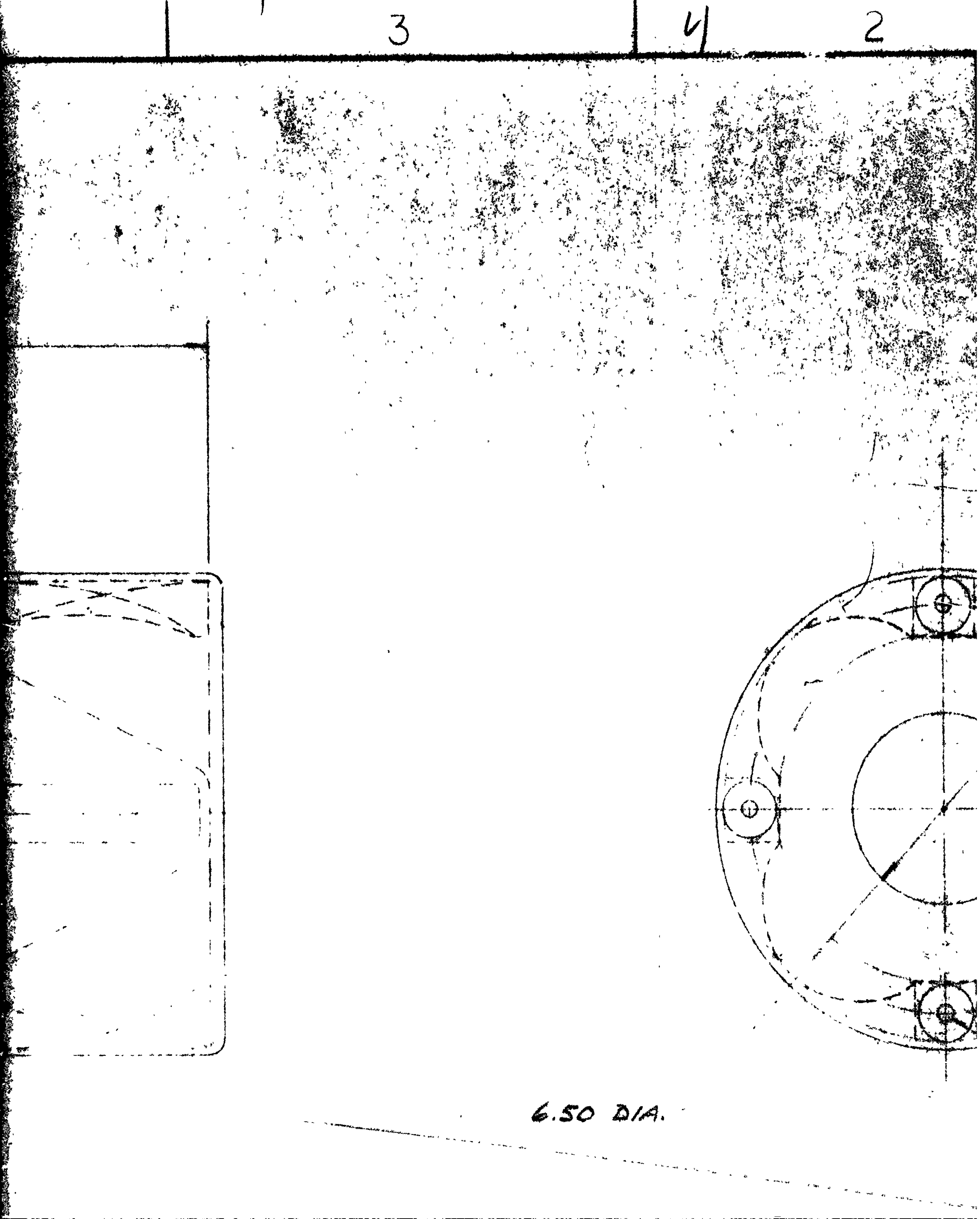
APPENDIX G

DRAWINGS


8
7
B


72.0"
16.0
B
t, THICK


5
3
4
16.00 DIA.
Wb
Ws
24°
24°
Ws
Wb
t, THICKNESS



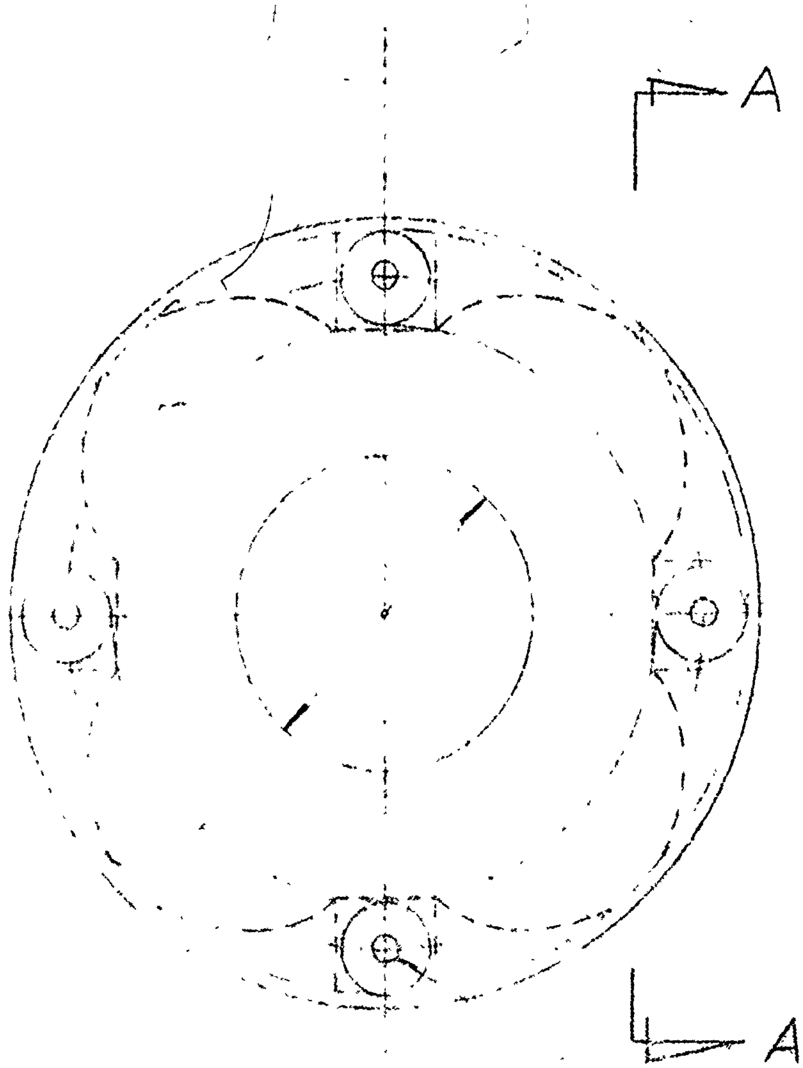
3
4
2
6.50 DIA.

4 2 1 5

REVISIONS

LTR	DESCRIPTION	DATE
A	INCORPORATED CHANGES PER ARMY REQUEST DATED 5 OCT 77	13 OCT 77

D

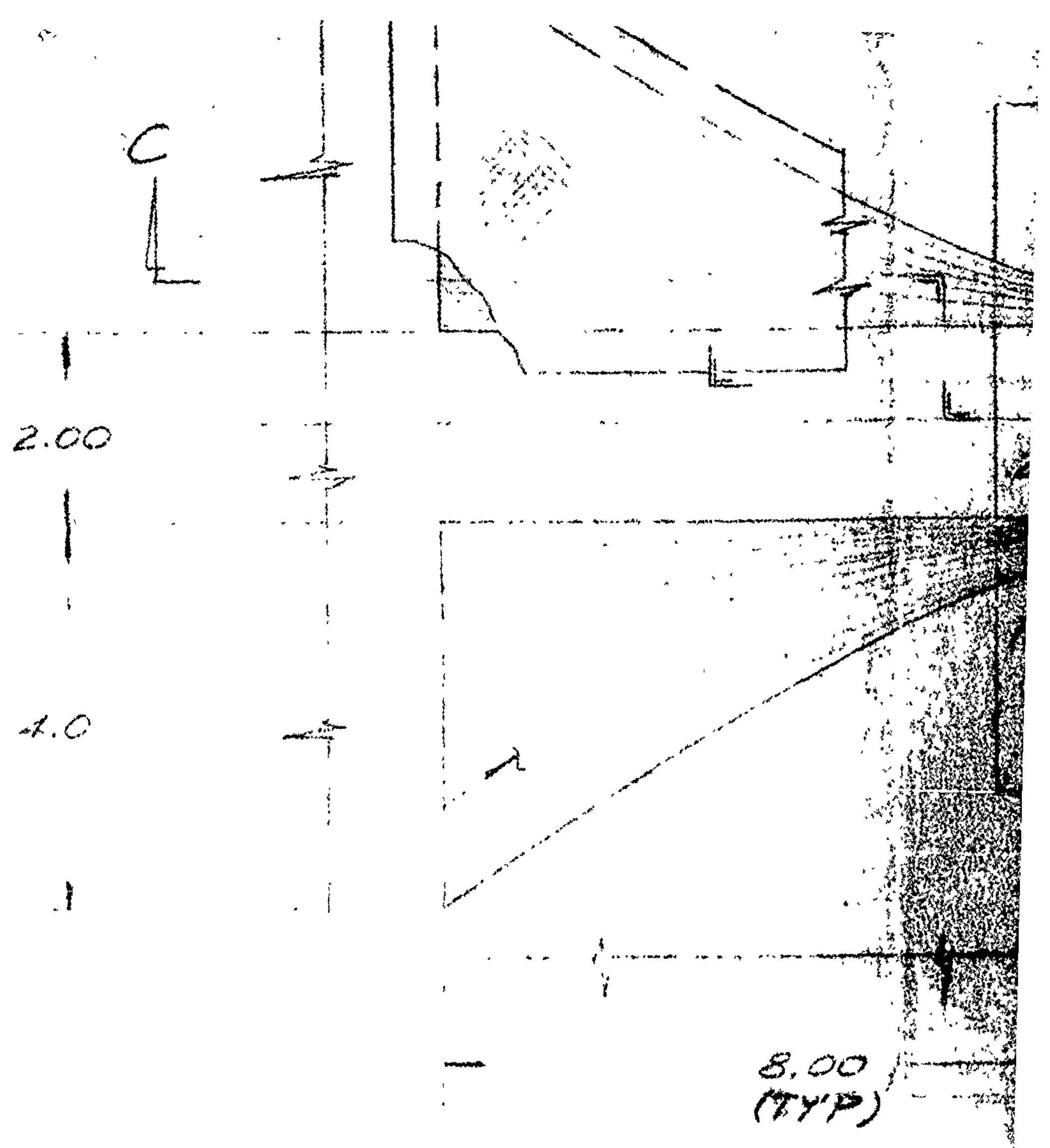


C

IA.

$.500 \pm^{.010}_{.000}$ DIA 4 HOLES
EQ. SPACED ON
14.000 DIA

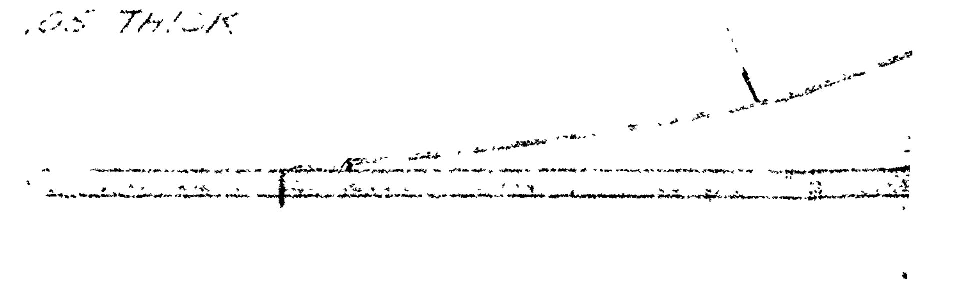
LONGO BROOM -
S-2 GLASS / EPOXY
$\alpha = 0°$



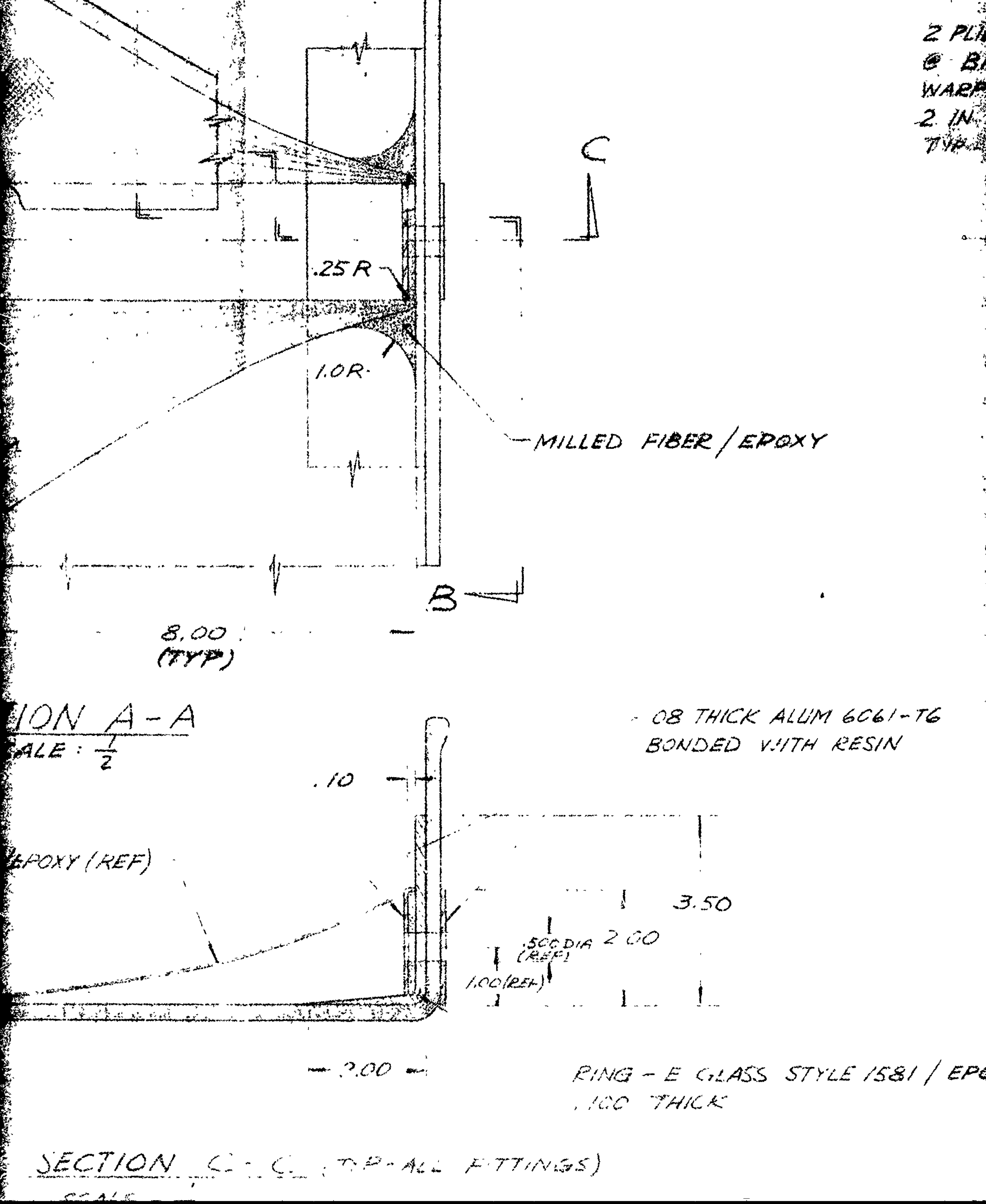
SECTION A - A
SCALE: $\frac{1}{2}$

GLASS FABRIC/EPOXY (REF)

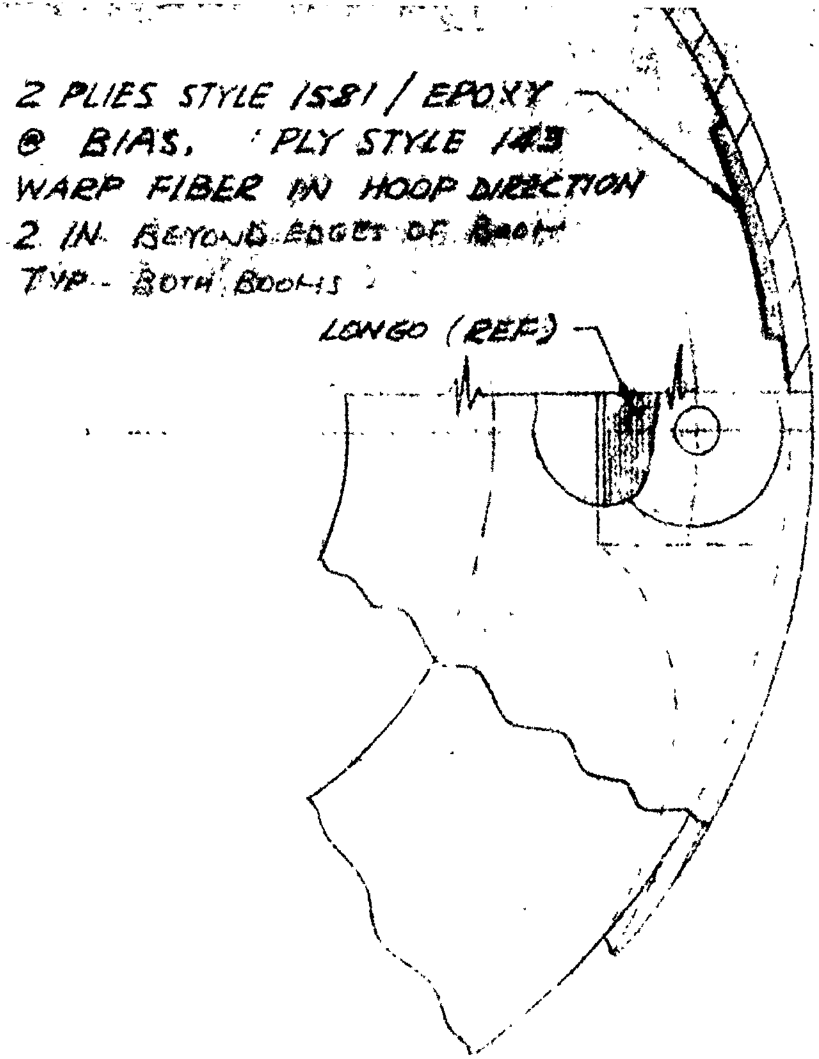
.05 THICK



SECTION C - C
SCALE : $\frac{1}{2}$



2 PL
@ B
WARP
2 IN
TYP
C
.25 R
1.0 R
MILLED FIBER / EPOXY
B
8.00
(TYP)
ION A-A
ALE : 1/2
.08 THICK ALUM 6061-T6
BONDED WITH RESIN
.10
EPOXY (REF)
3.50
.500 DIA
(REF)
2.00
1.00 (REF)
2.00
RING - E GLASS STYLE 1581 / EP
.100 THICK
SECTION C-C (TYP-ALL FITTINGS)



SECTION B-B
SCALE: $\frac{1}{2}$

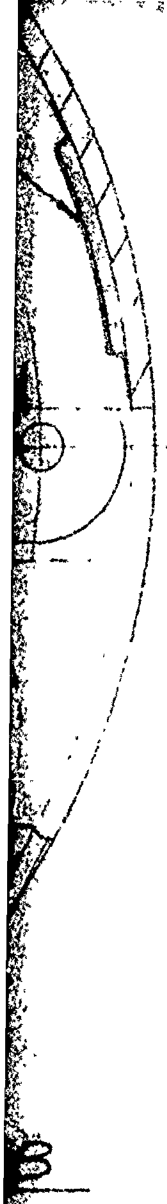
/EPOXY

ICK ALUM 6061-T6
ED WITH RESIN

50

F.C.R	$t_{CALC\ IN.}$	$t_{ACT.\ IN.}$	Wb
25%	.4081	.6530	.604
50%	.2084	.2918	.574

LASS STYLE 1581 / EPOXY



NOTES:

1. MATERIAL :

2. W_S
W_b
F.C.R.
F.C.R.

3. CONSTRUCT
80 %
20 %

4. FIBER VOLU
V_f = .
V_f = .3
V_f = .4

t_{CALC} IN.	t_{ACT}. IN.	Wb	Ws	NO. CIRC LAYER	NO OF HEL LAYERS	NO. OF HOOP PLY
.4081	6530	.604	1.813	19	32	17
.2084	.2918	.574	.574	40	15	9

END VIEW
TYPICAL BOTH ENDS

TERIAL : FIBER – KEVLAR 49 (V_f = .65 FOR t_{calc})
RESIN – EPON 826 / TONOX LC

W_s : SPACE WIDTH
W_b : BAND WIDTH
F.C.R. : FIBER COVER RATIO

$$F.C.R = \frac{W_b}{(W_b + W_s)} \times 100\%$$

NSTRUCTIONS :
80% OF t ± 24° HELICAL WINDINGS
20% OF t , 90° HOOP WINDINGS

BER VOLUME RATIO :
V_f = .50 ALL HOOP WINDINGS
V_f = .3714 HELICAL WINDINGS F.C.R = 25% FOR t_{actual}
V_f = .4333 HELICAL WINDINGS F.C.R = 50% FOR t_{actual}

B

A

FIBER SCIENCE, INC.
GARDENA, CALIFORNIA 90248

TITLE
FINAL DESIGN EVALUATION SPECIMEN,
SPACEWIND COMPOSITE STRUCTURE

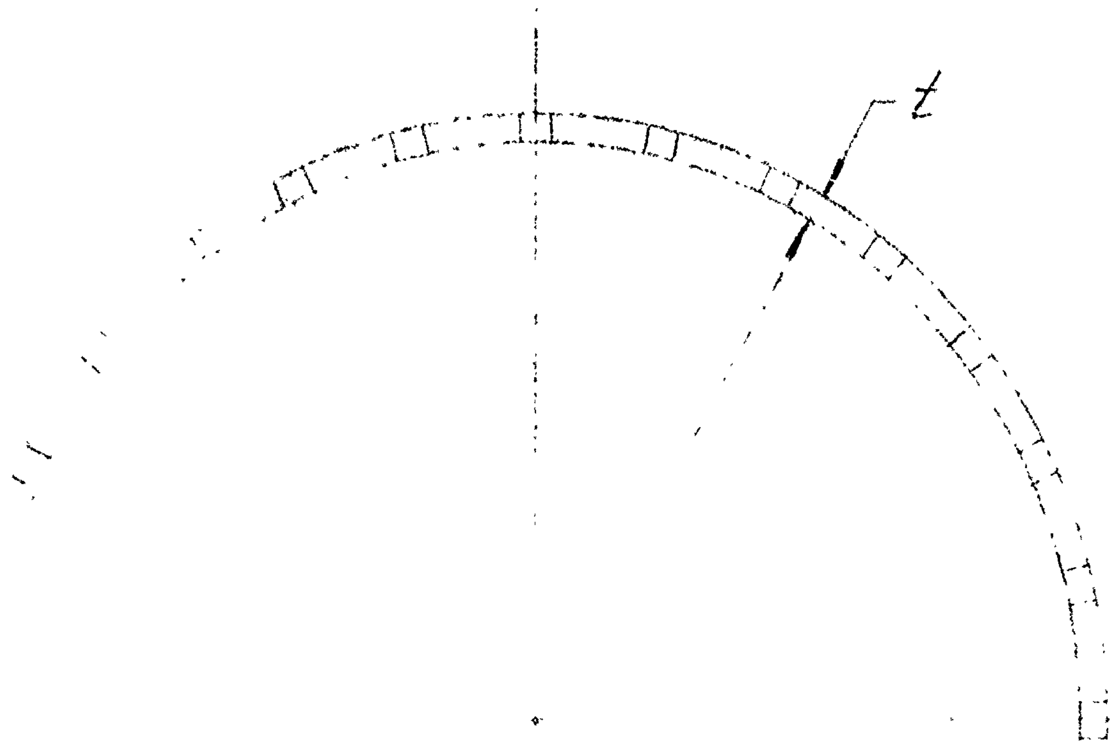
DWG SIZE	CODE IDENT	DWG NO.	
D	32500	1105 – 002	
SCALE 1/4 & NOTED		DRAWN CHU 9-14-71	SHEET 1 OF 1

NO	F.C.R.** %	F.A.C.R.*** %	MATERIAL	t IN.	Ws IN.	Wb IN.
1	25	57.81	S-2 GLASS	.526	1.85	.62
2	50	87.50	S-2 GLASS	.261	.62	.62
3	25	57.81	KEVLAR 49	.368	1.85	.62
4	50	87.50	KEVLAR 49	.185	.62	.62
5	25	57.81	THORNEL 300	.212	1.85	.62
6*	50	87.50	THORNEL 300	.106	1.85	.62

* SANDWICH WALL CONSTRUCTION: t_f = .053 IN., t_c = .

** F.C.R. = Wb/(Ws + Wb)

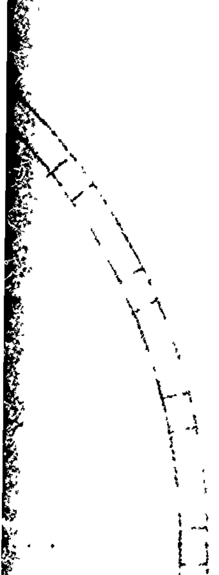
*** F.A.C.R. = FIBER COVER AREA / TOTAL AREA

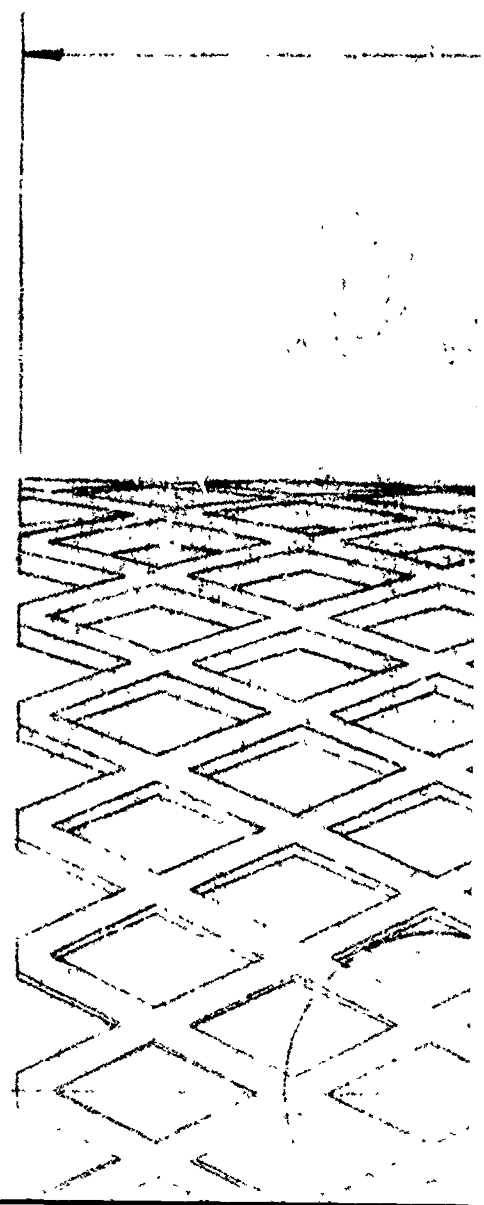


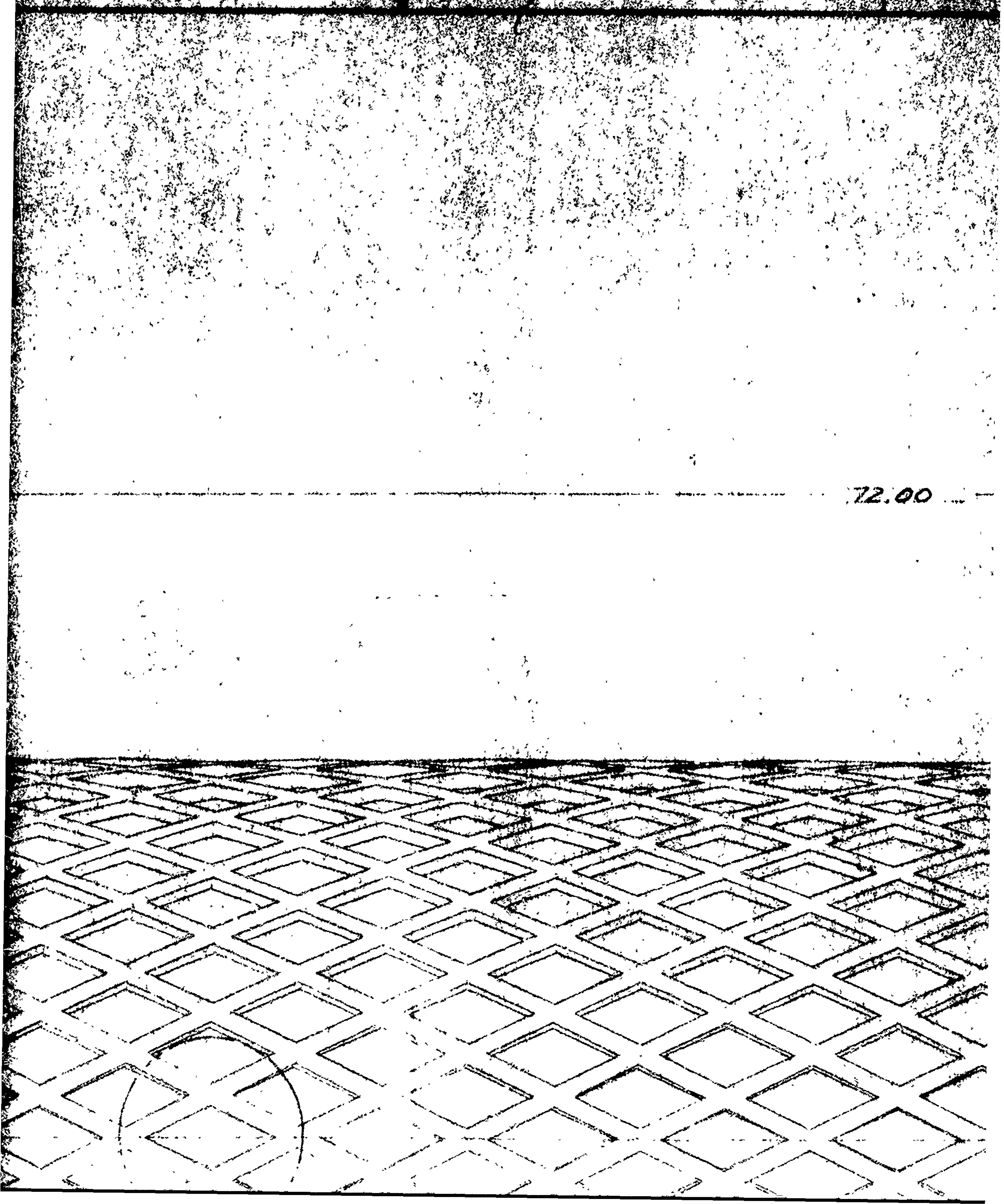
	Ws IN.	Wb IN.	NO. CIR / LAYER
	1.85	.62	28
	.62	.62	56
	1.85	.62	28
	.62	.62	56
	1.85	.62	28
	1.85	.62	56

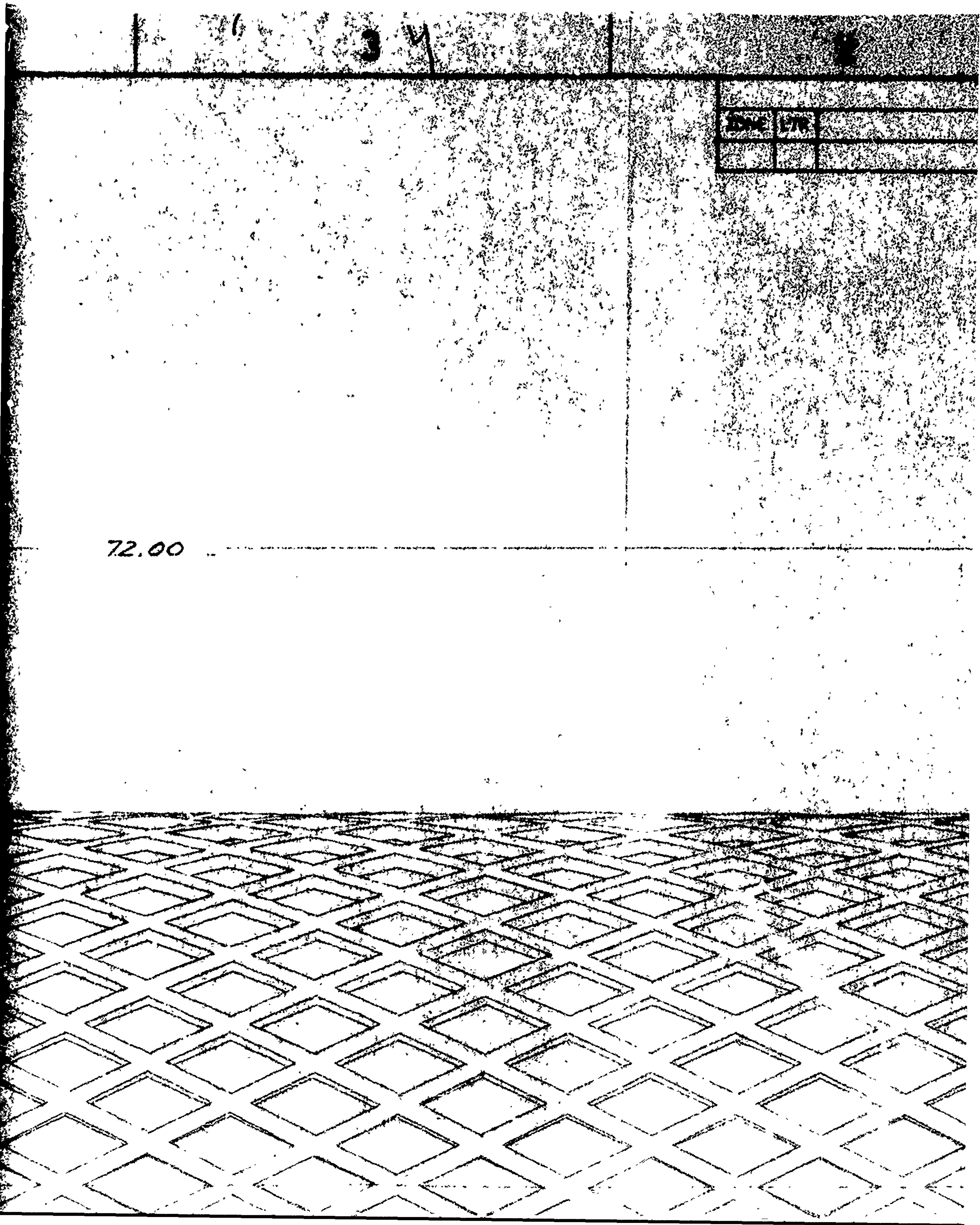
.053 IN. , t_c = .25 IN.

REA



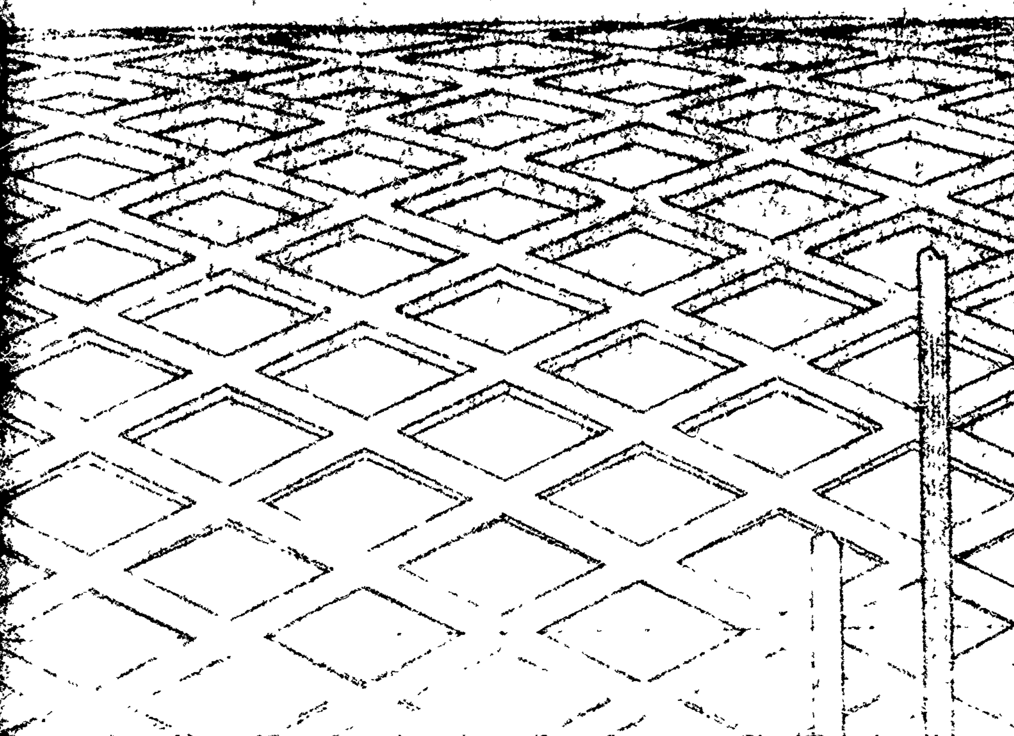


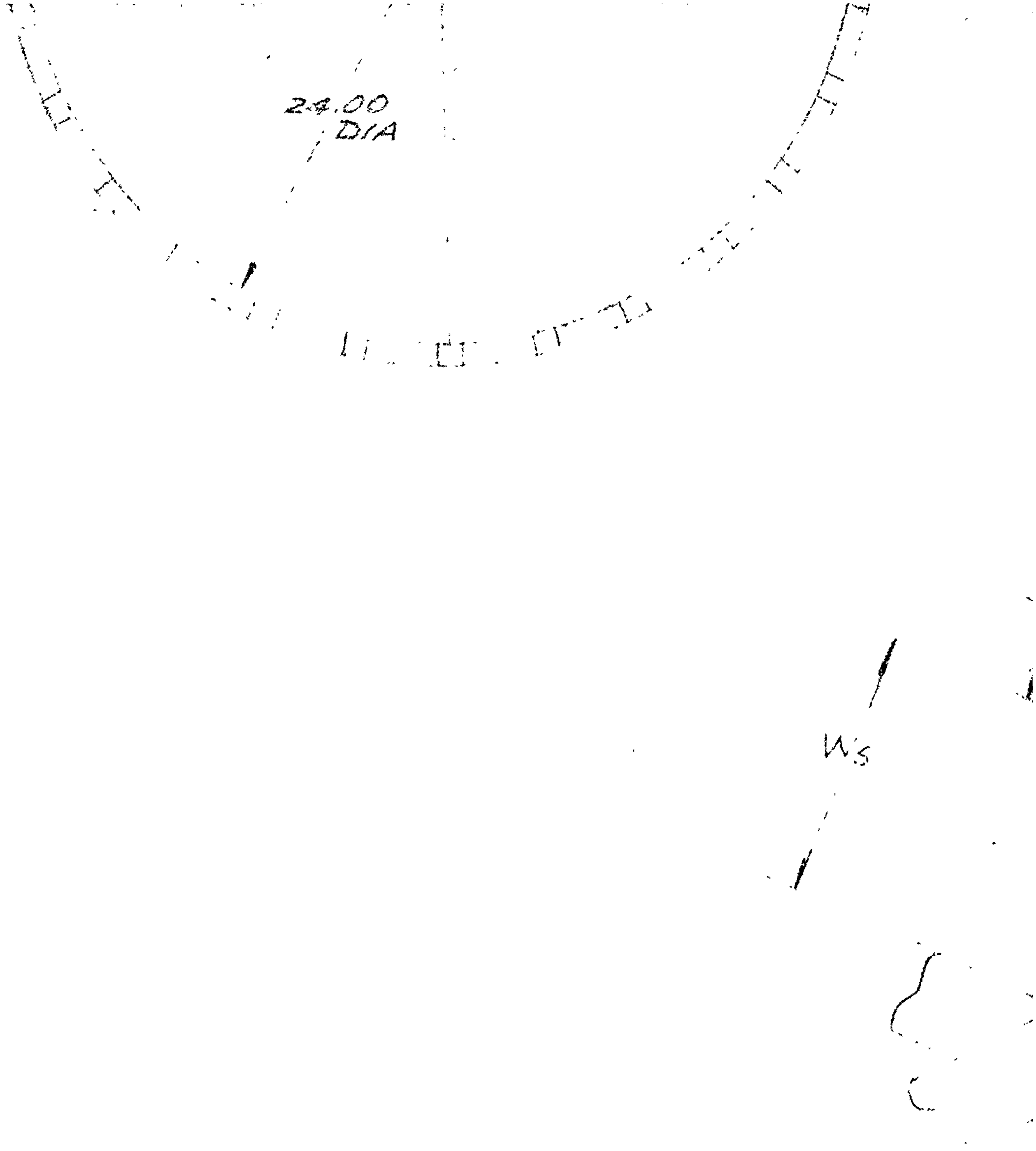

72.00


ZONE
LTR
72.00

REVISIONS

ZONE	LTR	DESCRIPTION	DATE	APPROVED

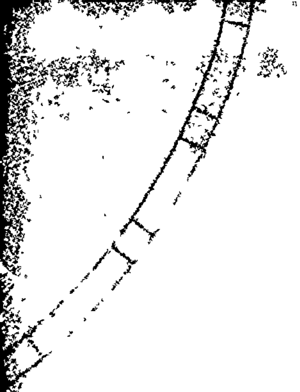


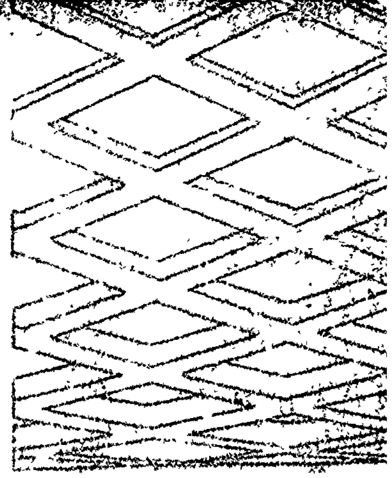


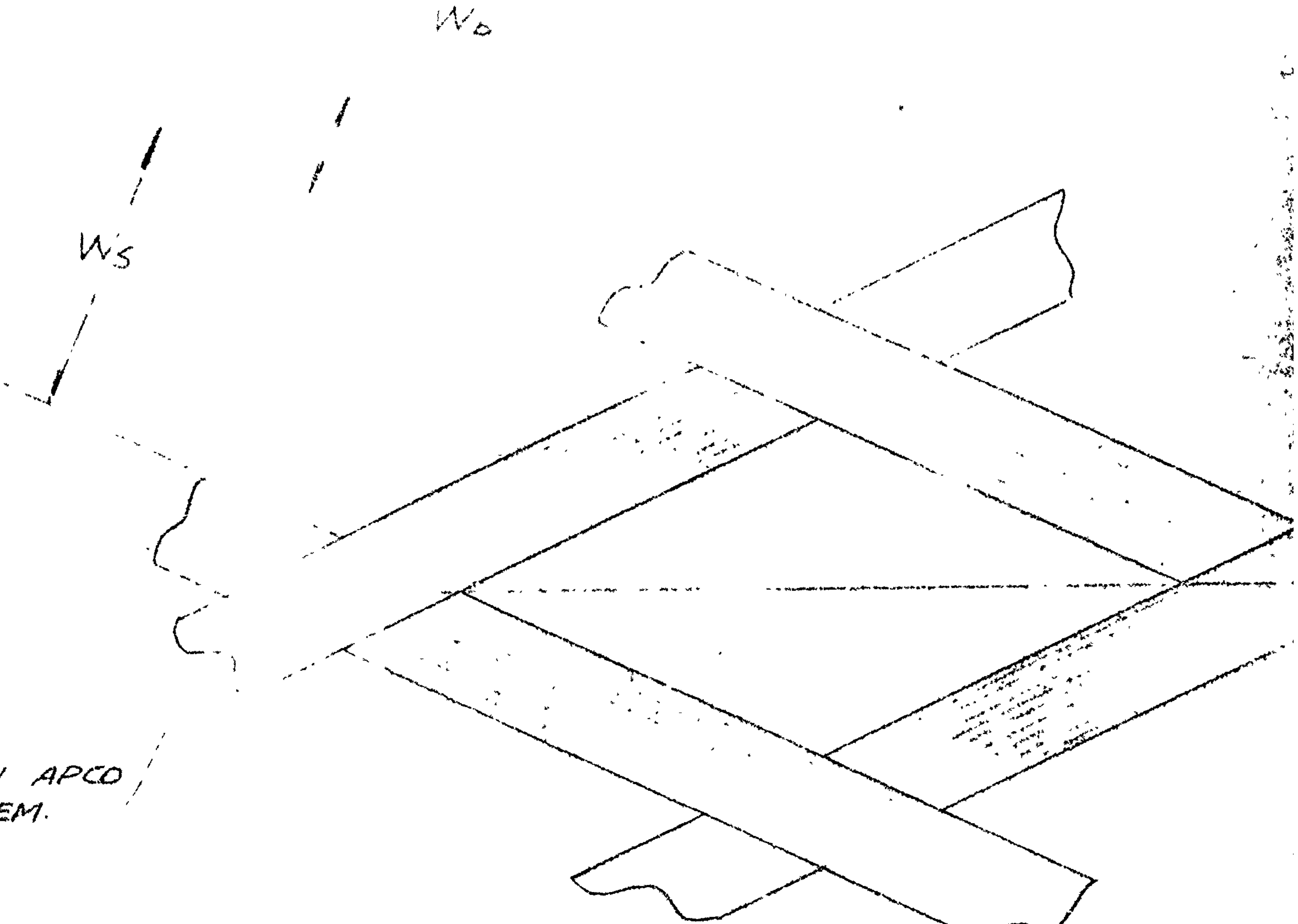
2 > ALL FIBER MATERIALS IMPREGNATED WITH APCO 2453 / APCO 2330 EPOXY RESIN SYSTEM.

1 CONSTRUCTION:
20 % ± 90° HOOP WINDING
80 % ± 24° HELICAL WINDING

NOTES:



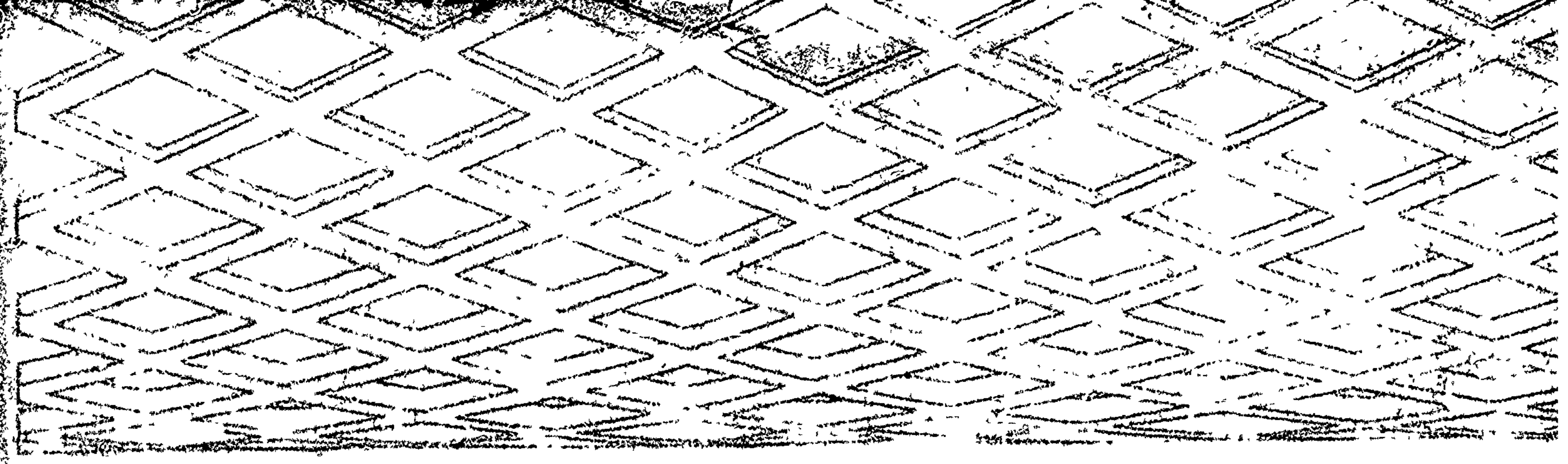


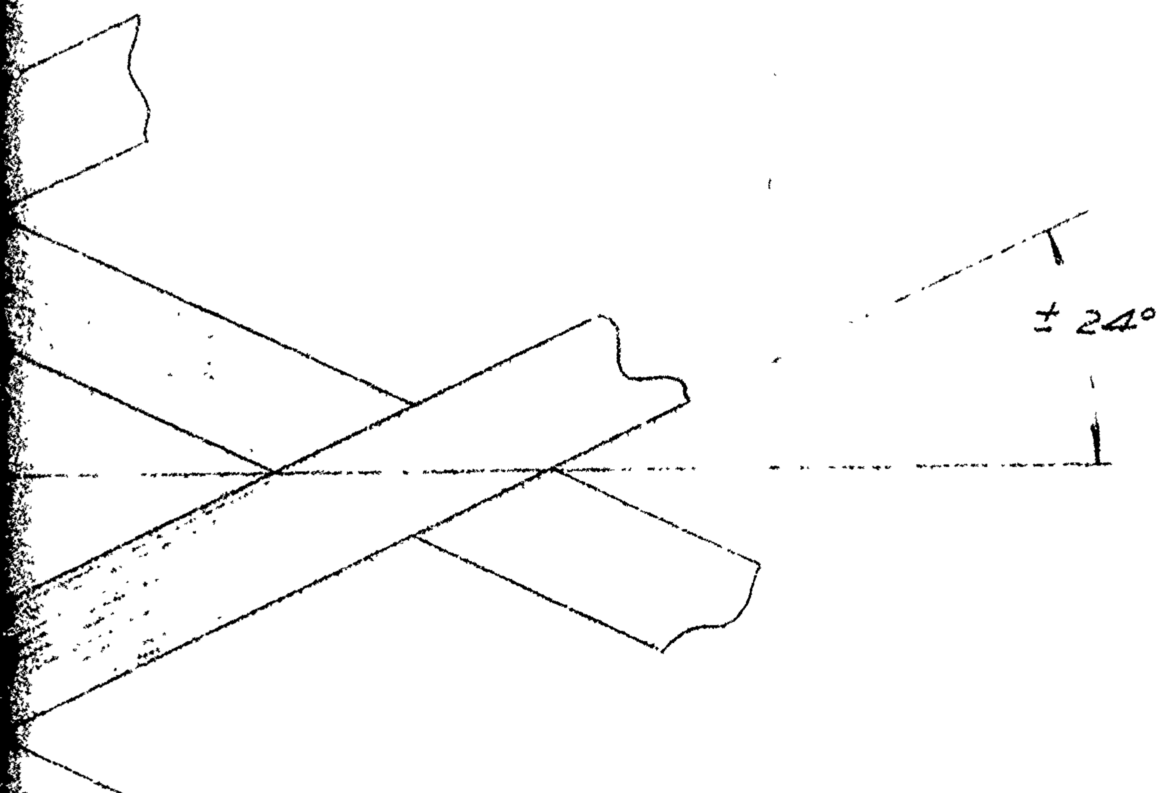


ITH APCO
STEM.

G

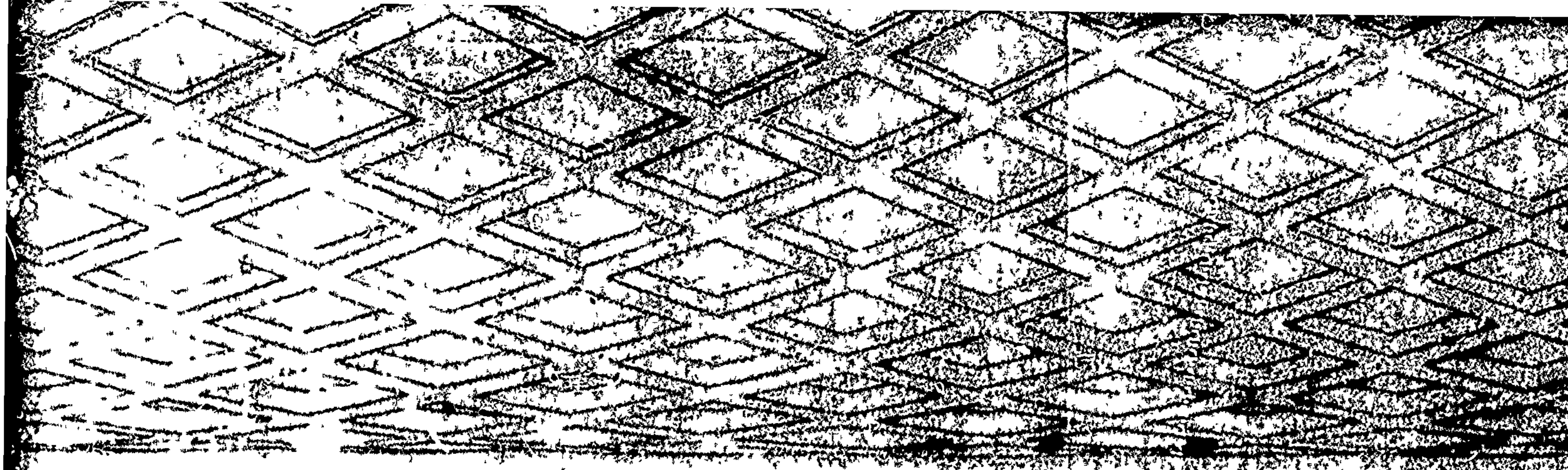
DETAIL A (HOOP WINDING NOT





P WINDING NOT SHOWN)

NEXT ASSY	



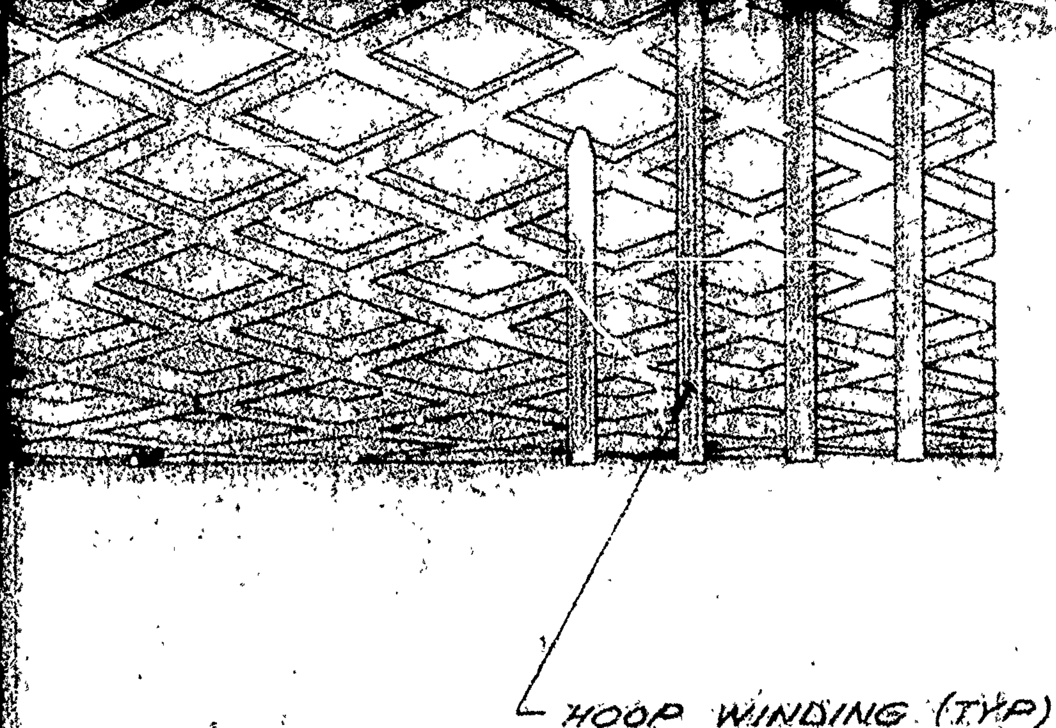
		CODE IDENT	PART NO.	DESCRIPTION
QTY REQD				LIST OF

UNLESS OTHERWISE NOTED
DIMENSIONS ARE IN INCHES
TOLERANCES
DECIMAL FINISH ANGULAR
XX ± .06 ± 1°
XXX ± .030
DO NOT SCALE

FINISH

		DATE
DRAWN	S. CHU	3-8-77
CHECK		
DESIGN		
STRESS		
ENGR		

T



	DESCRIPTION	MATERIAL	SPECIFICATION	ZONE	ITE NO

LIST OF MATERIALS

	DATE	
DRAWN S. CHU	3-8-77	**FIBER SCIENCE, INC.** GARDENA, CALIFORNIA 90248
CHECK		TITLE SPACEWOUND EVALUATION SPECIMEN
DESIGN		
STRESS		
ENGR		
DESIGN ACTIVITY APPD		DWG SIZE D · CODE IDENT 32500 · DWG NO. 1105-001

APPENDIX H

NOMENCLATURE

NOMENCLATURE

A	Area, in^2
B	Angle, deg.
C_c	Buckling coefficient
E_e	Modulus of elasticity, psi
F	Allowable stress, psi
FA	Fiber area per unit
FACR	Fiber area coverage ratio
FCR	Fiber coverage ratio
FCOA	Fiber cross-over area ratio
G	Shear modulus, psi
I	Moment of intertia, in^4
Io	Moment of inte ia about netral axis, in^4
IO	Inside diameter, in.
K	Torsional constant, in^4
L	Dimension, in.
M	Moment, in-lb
n	Coefficient
P	Load, lb
Q	Moment area, in^3
R	Radius, in.
$\bar{R}$	Mid wall radius, in.
S	Shear, lb
t	Thickness, in.
V	Volume ratio
W	Dimension, in.
y	Dimension, in.
α	Winding angle, deg.
ρ	Density, lb/in^3
σ	Unit stress, psi
τ	Unit shear stress, psi

SUBSCRIPTS

b	denotes band
bco	denotes between cross-overs
c	denotes composite or core
co	denotes cross-over
cr	denotes critical
cu	denotes compression ultimate
e	denotes equivalent
f	denotes fiber
fco	denotes fiber cross-over
fbco	denotes fiber between cross-overs
i	denotes inside
max	denotes maximum
o	denotes outside
su	denotes shear ultimate
x	denotes "x" direction
y	denotes "y" direction
z	denotes "z" direction
11	denotes direction parallel to fibers